NASA/DoD Aerospace Knowledge Diffusion Research Project

NASA Contractor Report 194973

Report Number 30

Computer-Mediated Communication (CMC) and the Communication of Technical Information in Aerospace

Daniel J. Murphy
SUNY Institute of Technology at Utica/Rome
P.O. Box 3050
Utica, New York 13504-3050

Prepared for Langley Research Center
under Purchase Order L-45107

December 1994

National Aeronautics and Space Administration

Department of Defense

INDIANA UNIVERSITY

CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

ACKNOWLEDGMENT

The ideas presented in this dissertation first began to take shape in the autumn of 1988 after I completed a co-op assignment as a technical writer and editor at an Upstate New York electronic training firm on the advice of Professor Philip Rubens. Had it not been for that experience, my research probably would taken a different course altogether. During the six years since then that I have been working to complete this dissertation, I have had the privilege of coming into contact with many people who have helped me in the effort. I regret that there is no way I could thank every one of them personally for the contributions each has made. Nevertheless, I would like to acknowledge several individuals who played important roles in the development of this dissertation.

I am thankful to Dr. Robert Krull, my thesis advisor, and to the other committee members from whom I have benefited because of their instruction and advice: Doctors Roger A. Grice, Teresa M. Harrison, Richard P. Leifer, and Philip M. Rubens.

I also extend special thanks to Dr. Thomas E. Pinelli who is the Assistant Director to the Chief of the Scientific and Technical Information Division at the NASA Langley Research Center and also the Director of the NASA/DoD Knowledge Diffusion Research Project, and to Dr. John Kennedy, Director of the Indiana University Center for Survey Research, for their generous support, advice, trust, time, and friendship. They and their colleagues, especially Rebecca Barclay, Ann Bishop, Laura Hecht, Nanci Glassman, and Tammi Taylor, were instrumental in the completion of this research effort.

I want to thank the Society for Technical Communication (STC) and its President, Mr. William Stolgitis, for the generous research grant that STC provided to me in 1992. Also, I am grateful for the research support I received from the State University of New York (SUNY) Institute of Technology at Utica/Rome and particularly thank Dr. Michael Spitzer, Dean of the School of Arts and Sciences, and Dr. Shirley Van Marter, Executive Vice President of Academic Affairs. I am also thankful to my SUNY colleagues who helped me with some of the technical aspects of the dissertation, especially Professors Linda Weber, Rosemary Mullick, V. K. Kool, Steven Schneider, and William Thistleton. I also acknowledge the helpful and timely advice I received from Dr. Ron Rice at the Rutgers School of Information and Library Science.

I am sincerely thankful for the support, love, hope, and prayers I received from all of my family. I am especially grateful to my wife, Mary, for her professional expertise and technical advice, but more importantly, for her patience, encouragement, and confidence. Also, I thank my many friends and my colleagues at RPI who helped me to stay the course.

And lastly, I remember my bagpipe band buddies for their spirit and motto: "Press on regardless." So, I did.

ABSTRACT

This dissertation is an empirical study examining the use of communication media in general, and electronic media specifically, in terms of the U.S. aerospace industry's scientific and technical information (STI) knowledge diffusion process. The volunteer subjects were 1,006 randomly selected U.S. aerospace engineers and scientists who belong to the American Institute of Aeronautics and Astronautics (AIAA). Quantitative data from the surveys were triangulated with qualitative information obtained from 32 AIAA members in telephone and face-to-face conversations. The Information Processing (IP) model developed by Tushman and Nadler (1978) and Daft and Lengel (1986) constituted the study's theoretical basis.

This field-study research project analyzed responses regarding communication methods of those who create, use, and disseminate aerospace STI. The study also explored contextual environmental variables related to media use and effective performance. The results indicate that uncertainty is significantly reduced in environments when levels of analyzability are high. When uncertainty is high, there is significantly more use of electronic media. However, no relation was found between overall effectiveness and media use in environments stratified by levels of analyzability or equivocality. Although most respondents reported that electronic networks are important for their work, the data suggest that there are sharply disparate levels of use.

The results indicate modest support for the influences of uncertainty and analyzability on electronic media use. The "fit" between IP requirements and capabilities that the model proposes is a contingency affecting overall employee effectiveness was not supported by the data.

PART 1

INTRODUCTION

1.1 Overview

This dissertation provides an empirical examination and assessment of the use of communication media in general, and electronic media specifically, in the U.S. aerospace industry's scientific and technical information (STI) knowledge diffusion process. To comprehend STI transfer involving aerospace technology, it is important to analyze the communication methods of those who create and use the information. Using several variables to analyze the environments and practices of U.S. aerospace engineers and scientists, we can better understand the communication processes in federal STI dissemination (Kennedy, Pinelli, Hecht, & Barclay, 1994). (See Appendix A for information regarding the commission to gather the research data under the auspices of the NASA/DoD Knowledge Diffusion Research Project.)

The research involved a non-experimental inquiry to discover relations and interactions among specified communication and organizational variables in real social structures. As a field-study endeavor, it systematically pursued relations, tested hypotheses, and presented findings. Kerlinger (1986) stated that field study research is strong in realism, significance, strength of variables, theory orientation, and heuristic quality; however, there are limitations to research using questionnaires and surveys: a survey is not a precise measuring instrument, nor is survey research an exact science. No claim is being

made for data precision that surveys are inherently incapable of providing. However, Hoinville and Jowell (1978) do assert that systematic sample surveys provide more accurate measurements of a population's characteristics than do casual observations. Because questionnaire research, coupled with triangulation, offers a mechanism to garner information from a representative sample of a population, it enables us to seek a context for making better-informed judgments and better-directed decisions.

To manage these information activities as they continue to proliferate, many enterprises may find that they will require the use of ever-more sophisticated information processing capabilities (Daft & Lengel, 1986; Gratz & Salem, 1984; Huber, 1984; Tushman & Nadler, 1978). As probable as that may be, however, for many years postindustrial society's exchange of information had, despite improvements in the speed of mail and the use of telemedia such as television and radio, been largely confined to communication methods that did not easily permit people to exchange information among and between themselves: it was frequently necessary to meet face-to-face to discuss problems and make decisions (Hiltz & Turoff, 1978).

Within the last twenty years, however, the emergence of computer-mediated communication (CMC) mechanisms ushered in a new age of communication capability (Behan & Holmes, 1986; Burns, 1984; Mandell, 1989; Rademacher & Gibson, 1983; Silver & Silver, 1986; Turski, 1985). CMC mechanisms, utilizing the computer as the means of structuring, storing, and processing written communications among groups of

persons, permit interaction conveniently and rapidly with near or distant persons and/or groups having similar concerns, interests, and goals (Hiltz & Turoff, 1978). The interactions occur through an electronic matrix of computers linked to each other in a network. The original objective of computer networks was resource sharing: allowing users to access the resources of another computer such as central processing unit (CPU) speed, storage space, programs, databases, or printers (Quarterman & Hoskins, 1986). However, networks also allow users to communicate with each other, and it is this type of information exchange that is now commonly called computer-mediated communication (CMC) (Quarterman, 1990).

Because CMC is a rapidly expanding method for information exchanges within the United States (Chesebro & Bonsall, 1989) and also alters how people complete their work (McCullough, 1984), technology and communication are closely interrelated (Hiltz & Turoff, 1978). This trend continues to increase (Kling, 1980), and traditional modes of information distribution such as paper mail delivery are being replaced at an ever-accelerating pace by CMC systems (Beniger, 1991; Luyken, 1987). But to what extent and how effectively is CMC (and other communication media) used for the diffusion of technical information, and can media effectiveness be assessed? This dissertation addresses these and other questions later posited in the form of testable hypotheses in Part 3. It begins with a theoretical model to deduce testable hypotheses, operationalizes them, and tests them by collecting and analyzing empirical data.

1.2 Definition of Key Terms

This section defines certain terms, concepts, and specialized vocabulary used in the study: communication, computer-mediated communication (CMC), organization, department, effectiveness, information, variety, analyzability, uncertainty, equivocality, and media richness. The author acknowledges that there may be various definitions for terms used in this dissertation, but for the purposes of this study, the definitions specified below are based primarily on a review of the IP literature for the past several years which includes seminal works in the field. The author has made a consistent effort to apply the definitions in the same contexts as they were originally discussed in the literature.

In this dissertation, communication refers to the processes by which information is transmitted and exchanged, and computer-mediated communication (CMC) means any communicative processes or exchanges that occur through the medium of a computer to create, address, route, distribute, or receive messages sent from one individual to another, from a group to an individual, from an individual to a group, or from one group to another group (Caswell, 1988; Hiltz & Turoff, 1978). This definition and the study's data collection exclude "computer" or "system" messages.

Organizations are defined here as social devices for efficiently accomplishing some stated purpose by using group means (Katz & Kahn, 1966). This implies the functioning of an overall system (here, the U.S. aerospace community) where interrelated behaviors of people performing

tasks are differentiated into subgroups and then integrated to achieve effective performance (Lawrence & Lorsch, 1967b). A department is a formally specified work group within the organization, headed by a manager and charged with a set of responsibilities to achieve organizational goals (Duncan, 1973).

While a variety of models and indicators of effectiveness have been developed and continue to be discussed in the literature (Strasser & Denniston, 1979), the term effectiveness in this context refers to the extent to which the system is able to obtain desired states by planning, organizing, and communicating. It should be noted that there is no single, unambiguous definition of overall organizational effectiveness (Quinn & Cameron, 1983; Seashore, Indik, & Georgopoulos, 1960; Tichy, 1983). That having been said, the basic definition of effectiveness this dissertation relies on is Cummings' (1980, pp. 105 & 111) assertion that it is "the extent of fit between the organization's environment and all the internal components of the [organization's] social system." Cummings' definition is used because it relies on several research studies that lend support for the definition: (Burns & Stalker, 1961; Lawrence & Lorsch, 1967a; Miles & Snow, 1978; Morse & Lorsch, 1970; Woodward, 1965). The specific methodology to assess effectiveness is explained in greater detail in Part 4.

The concept of information is also not simple to define. Hiltz and Turoff (1978, p. 454) for instance, say that:

> . . . we do not understand the nature of information. We have accepted, to a large extent, the continuing trend toward an

information-oriented society. However, we do not comprehend the dominant commodity of exchange in that society.

Nevertheless, information is an important term and deserves explanation to the extent that it can be rendered. One step toward this definition is to distinguish between data and information. Data is different from information in that data consists of isolated facts. A data item might be, for example, "130 diesel-powered turbines." It is only when data is processed or associated with other data in contexts that enable or facilitate interpretation that one has useful information that can lead to actions or to decisions. Information is data supplied in the right form, at the right time, to the right people, and in the right place to persuade individuals to either take action or reach good decisions.

For example, suppose that a large corporation regularly received its long-distance telephone bills printed on many thousands of pages of paper; the data contained in the document would not be readily amenable to interpretation. However, suppose instead that the data were supplied to the corporation in a digitized format, such as a computer diskette, that facilitated computerized Boolean or key-word searches. Such a change in the data could enable interested individuals to identify corporate patterns of telephone usage involving chronological and geographical variables. In that case, the data could then become valuable information to those persons who may want to interpret the calling trends, perhaps with a view toward developing new policies to reduce corporate long-distance telephone expenditures. In other words, it is information that is necessary to make well-informed decisions (Behan & Holmes, 1986). We may

therefore conceive of information as "data + meaning" (Checkland, 1986, p. 328).

Information also implies the reduction of uncertainty (Duncan, 1972; Lawrence & Lorsch, 1967b). This defines information in terms of the value of the messages as derived from impact upon some user's productivity or decision-making process. In other words, a message or information item is not valuable if it is always the same, may be readily predicted, or is not amenable to interpretation. If information is to be really valuable, Mader (1979) believes that it must:

1) have some element of surprise;
2) affect some decision that depends on it; and,
3) produce improved outcomes.

Basically, the most valuable information is that which is "accurate, verifiable, timely, complete, and clear" (Mandell, 1989, p. 59).

<u>Variety</u> is defined as the measure of unique or unanticipated events or situations that individuals routinely encounter. Low variety is characterized by few problems that may occur infrequently. High variety implies that there are frequently new problems occurring that require novel approaches to understand and eliminate the problems (Daft & Macintosh, 1981).

<u>Analyzability</u> is somewhat related to variety. To the extent that problems may be anticipated, solutions may also be planned to cope with the problems when they do occur. Low analyzability means that problems may not be readily amenable to careful scrutiny to provide formal procedures to deal with the difficulties when they do occur. High

analyzability refers to a high capacity to provide procedural methods to solve problems (Daft & Macintosh, 1981).

This dissertation uses Galbraith's (1973) definition of uncertainty because it is derived from his seminal work and is widely used in the IP literature. It is defined as the difference that exists between the amount of information that is required and the amount of information that is possessed by individuals. It implies that explicit questions can be formulated and that specific answers exist somewhere in the organization (Galbraith, 1973). The author is not aware of any discussion in the IP literature that claims some level of uncertainty may be good or valuable.

Equivocality implies an unclear field caused by ambiguity or the existence of multiple and conflicting interpretations resulting in confusion and lack of understanding. It differs from uncertainty in that no certain answers exist and perhaps the right questions have yet to be formulated (Daft, Lengel, & Trevino, 1987).

Media richness is defined as the ability of information to change understanding within a time interval; that is, communications that overcome frames of reference or clarify ambiguity in a timely manner are defined as rich. Rich media tend to be characterized by their ability to carry greater amounts of non-verbal context cues (Daft & Lengel, 1986; Rice, 1992). More detailed explanations of this concept and the other variables defined above are offered in Part 2, Theory.

1.3 Research Objectives

Lawrence and Lorsch (1967a, 1967b) held that successful enterprises are able to diversify as well as integrate. Differentiation, that is, segmentation, is desirable because it permits task accomplishment by experts of the tasks at hand. Consequently, integration is necessary to connect the individuated parts of the organization into a productive whole. After the work of Lawrence and Lorsch (1967a, 1967b), it became useful to see organizations as groups that integrate and collaborate in meaningful ways to obtain unity of effort to accomplish the organization's goals. But, differentiation tends to generate conflict. Thus, interdependence of diverse activities requires greater information processing to resolve the problems brought about by diversity (Hage, Aiken, & Marrett, 1971). When diversity and interdependence are unified effectively to achieve goals, one would say the enterprise enjoys successful integration. Hence, effectiveness is in a great measure tied to the principal means of integration—communication. It therefore becomes apparent that to facilitate the transfer of STI across diverse groups working toward common goals, communication is essential to optimize overall effectiveness. Toward these ends, the IP model used in this study assesses variables associated with the task environments of the workers, such as levels of variety and analyzability, as well as communication variables, such as frequency of use of certain media discussed in detail in Part 2.

This research into the task environments of aerospace engineers and scientists uses a model that views enterprises as entities or perhaps more accurately, as social systems that process information (Daft & Lengel,

1986; Galbraith, 1973; Thompson, 1967; Tushman & Nadler, 1978). The Information Processing (IP) model (Daft & Lengel, 1986; Triscari, 1984; Tushman & Nadler, 1978) serves as the theoretical basis to investigate the use of communication media in aerospace STI activities. A fundamental theoretical proposition in this framework is that overall effectiveness is a function of information-sharing activities.

The IP model proposes that information capabilities and requirements are influenced by contextual variables of organizational design (i.e., variables associated with the task environments of the workers, such as variety and analyzability) . Kraemer and Pinsonneault (1990) define contextual variables as those factors relevant to the task environments of the individual workers, such as the relative amounts of variety that they may have to cope with in order to accomplish their tasks. To examine these hypothesized relationships in this research, a theoretical proposition of the model is that overall effectiveness is a function of information-sharing activity (Daft & Lengel, 1986; Leifer & Triscari, 1987; Tushman & Nadler, 1978) as discussed in detail in Part 2 of this dissertation.

The focus of the study is to explore federal STI transfer as it is carried out among the developers and users of aerospace information. The basis of the inquiry is predicated upon the operationalization of IP theory, within the constraints of the variables to be explained in Part 2. The subjects of the study work principally on U.S. aerospace research and development, although other areas such as academic research are

represented as well. A breakdown of specific areas is contained in Part 5 which reports the results of the study.

The objectives of the investigation include:

1. researching the use and functionality of CMC mechanisms by individuals in their work environments;
2. studying relationships among selected contextual variables (environmental factors such as variety and analyzability described in Part 2) and the information-sharing requirements of aerospace workers;
3. investigating relationships among selected organization design variables (coordination mechanisms and media explained in detail in Part 2) and communication capabilities;
4. exploring the function of fit between the information-sharing capabilities and requirements of aerospace workers; and,
5. evaluating the sufficiency of the IP model.

In their conclusion of "Information Processing Capabilities and Organizational Design: A Model and Field Study" Balaguer and Leifer (1989) called for ". . . further research and development of the information processing [IP model] approach for organizational design (p. 30)" within field settings to allow for the development of new dimensions or constructs. This research is directed in part toward that objective.

1.4 Organization of the Dissertation

Part 1 of this dissertation, "Introduction," provides a background to the discussion, defines several key terms, and provides preliminary

direction to the dissertation. It also specifies topics of particular interest to the research.

Part 2, "Theory," consists of a literature review and overall conceptual framework to formulate the theoretical approaches to be used in the investigation. It discusses communication needs and capabilities. It provides the theoretical groundwork relative to the relationship between media and the organizational variables that the research examines.

Part 3, "Hypotheses," specifies the hypotheses derived from Information Processing theory that will be tested in the study.

Part 4, "Methods," describes the data collection instrument, research strategies, and the statistical measures used to gather and interpret the data.

Part 5, "Results," provides a summary of the statistical findings. It discusses the extent to which the empirical evidence lends support to the hypotheses offered in Part 3.

Lastly, Part 6, "Discussion and Conclusion," interprets the results of the previous section and discusses the implications of the findings. It offers alternative ways to understand the data with respect to the IP model and makes suggestions for further research.

REFERENCES CITED IN PART 1

Balaguer, N. S., & Leifer, R. P. (1989). Information processing capabilities and organizational design: A model and field study. (Working paper), Harvard Business School, Cambridge, MA, and Rensselaer Polytechnic Institute School of Management, Troy, NY.

Behan, K., & Holmes, D. (1986). Understanding information technology: Text, readings, and cases. Englewood Cliffs, NJ: Prentice-Hall.

Beniger, J. R. (1991). Information society and global science. In C. Dunlop & R. Kling (Eds.), Computerization and controversy: Value conflicts and social choices (pp. 383–397). San Diego: Academic Press.

Burns, A. (Ed.). (1984). New information technology. New York: Halsted.

Burns, T., & Stalker, G. M. (1961). The management of innovation. London: Tavistock.

Checkland, P. B. (1986). Systems theory and information systems. In B. Langefors, A. A. Verrijn-Stuart, & G. Bracchi (Eds.), Trends in information systems (pp. 327–339). New York: Elsevier.

Chesebro, J. W., & Bonsall, D. G. (1989). Computer-mediated communication: Human relationships in a computerized world. Tuscaloosa: University of Alabama Press.

Cummings, T. G. (1980). Systems theory for organizational development. New York: Wiley.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. Management Science, 32, 554–571.

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection, and manager performance: Implications for information systems. Management Information Systems Quarterly, 11, 355–366.

Daft, R. L., & Macintosh, N. B. (1981). A tentative exploration into the amount and equivocality of information processing in organizational work units. Administrative Science Quarterly, 26, 207–224.

Duncan, R. B. (1972). Characteristics of organizational environments and perceived uncertainty. Administrative Science Quarterly, 17, 313–327.

Duncan, R. B. (1973). Multiple decision-making structures in adapting to environmental uncertainty: The impact on organizational effectiveness. Human Relations, 26(3), 273–291.

Galbraith, J. R. (1973). Designing complex organizations. Reading, MA: Addison-Wesley.

Gratz, R. D., & Salem, P. J. (1984). Technology and the crisis of self. Communication Quarterly, 32, 98–103.

Hage, J., Aiken, M., & Marrett, C. B. (1971). Organization structure and communications. American Sociological Review, 36, 860–871.

Hiltz, S. R., & Turoff, M. (1978). The network nation: Human communication via computer. Reading, MA: Addison-Wesley.

Hoinville, G., & Jowell, R. (1978). Survey research practice. London: Heinemann.

Huber, G. P. (1984). The nature and design of post-industrial organizations. Management Science, 30, 928–951.

Katz, D., & Kahn, R. L. (1966). The social psychology of organizations. New York: Wiley.

Kennedy, J. M., Pinelli, T. E., Hecht, L. F., & Barclay, R. O. (1994). An analysis of the transfer of scientific and technical communications in aerospace. Annual Meeting of the American Sociological Association, Los Angeles.

Kerlinger, F. N. (1986). Foundations of behavioral research (3rd ed.). Fort Worth: Holt, Rinehart and Winston.

Kling, R. (1980). Social analysis of computing: Theoretical perspectives in recent empirical research. Computing Surveys, 12, 61–110.

Kraemer, K. L., & Pinsonneault, A. (1990). Technology and groups: Assessment of the empirical research. In J. Galegher, R. Kraut, & C. Egido (Eds.), Intellectual teamwork: Social and technological foundations of cooperative work (pp. 375–405). Hillsdale, NJ: Lawrence Erlbaum.

Lawrence, P. R., & Lorsch, J. W. (1967a). Differentiation and integration in complex organizations. Administrative Science Quarterly, 12, 1–47.

Lawrence, P. R., & Lorsch, J. W. (1967b). Organization and environment. Homewood, IL: Richard Irwin.

Leifer, R., & Triscari, T. (1987). Organizational information processing characteristics and computer based information systems design. (Working paper), Rensselaer Polytechnic Institute School of Management, Troy, NY.

Luyken, G. M. (1987). New compunications [sic] technology. In J. D. Slack & F. Fejes (Eds.), The ideology of the information age (pp. 220–242). Norwood, NJ: Ablex.

Mader, C. (1979). Information systems: Technology, economics, applications, management (2nd ed.). Chicago: Science Research Associates.

Mandell, S. L. (1989). Computers and information processing: The complete course (5th ed.). St. Paul: West.

McCullough, P. (1984). Fundamentals of IBM computer systems. Chicago: Science Research Associates.

Miles, R. E., & Snow, C. C. (1978). Organization strategy structure and process. New York: McGraw-Hill.

Morse, J. J., & Lorsch, J. W. (1970). Beyond theory Y. Harvard Business Review, 62(1), 1–8.

Quarterman, J. S. (1990). The matrix: Computer networks and conferencing systems worldwide. Bedford, MA: Digital Press.

Quarterman, J. S., & Hoskins, J. C. (1986). Notable computer networks. Communications of the ACM, 29, 932–971.

Quinn, R. E., & Cameron, K. (1983). Organizational life cycles and shifting criteria of effectiveness: Some preliminary evidence. Management Science, 29, 33–51.

Rademacher, R. A., & Gibson, H. L. (1983). An introduction to computers and information systems. Cincinnati: South-Western.

Rice, R. E. (1992). Task analyzability, use of new media, and effectiveness: A multi-site exploration of media richness. Organization Science, 3(4), 475–500.

Seashore, S., Indik, B., & Georgopoulos, B. (1960). Relationships among criteria of job performance. Journal of Applied Psychology, 44, 195–202.

Silver, G. A., & Silver, M. L. (1986). Computers and information processing. New York: Harper and Row.

Strasser, S., & Denniston, O. L. (1979). A comparative analysis of goal and system models designed to evaluate health organization effectiveness. Academy of Management Proceedings, pp. 342–346.

Thompson, J. D. (1967). Organizations in action. New York: McGraw-Hill.

Tichy, N. M. (1983). Managing strategic change. New York: Wiley.

Triscari, T. (1984). Organizations and information processing: A field study of research and development units within the United States Air Force systems command. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Turski, W. M. (1985). Informatics: A propaedeutic view (B. Osuchowska, Trans.). (2nd ed.). New York: Elsevier.

Tushman, M. L., & Nadler, D. A. (1978). Information processing as an integrating concept in organizational design. Academy of Management Review, 3, 613–624.

Woodward, J. (1965). Industrial organization: Theory and practice. London: Oxford University Press.

PART 2

THEORY

2.1 The Information Processing (IP) Approach to Communication

2.1.1 Overview

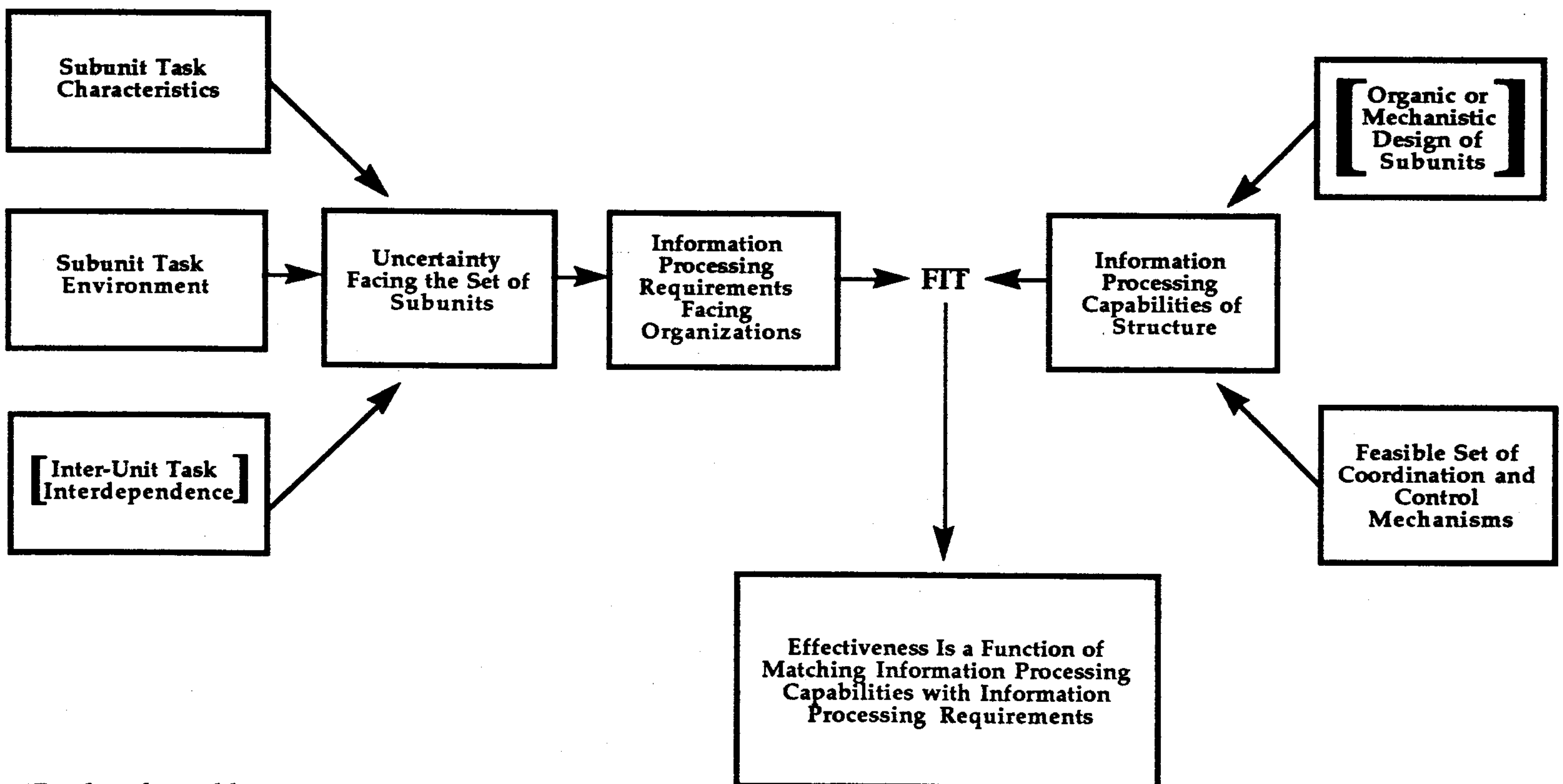
The theoretical framework adopted for this research is principally grounded upon the Tushman and Nadler (1978) Model of Information Processing (IP) as developed after the work of Galbraith (1973). Illustrated in Figure 2–1, this model proposes that a proper degree of fit between the information requirements of the workers and the organizations' information processing capabilities must be realized to increase overall effectiveness. It claims that improper fit can cause individuals' job performances to lag behind their goals or expectations, resulting in problems or negative consequences. To achieve strategic ends, it is therefore necessary to manage information as part of the overall work process (Allen & Hauptman, 1987), and this should best be accomplished by enabling communication capabilities to match needs.

2.1.2 Contents

Section 2.2 reviews central concepts in information processing theory. Section 2.3 explains the IP requirements from uncertainty and equivocality. Section 2.4 describes the contextual variables (i.e., task environments of the research subjects) associated with task technology. Section 2.5 covers IP capabilities of the organizational design variables regarding information quantity, information richness, and the

Figure 2-1

Summary of Tushman and Nadler Information Processing (IP) Model (1978)



*Bracketed variables not used in hypothesis testing

coordination mechanisms (operationalized as media components). Section 2.6 summarizes the research framework that leads to the hypotheses that are later presented in Part 3.

2.2 Concepts in Information Processing (IP) Theory

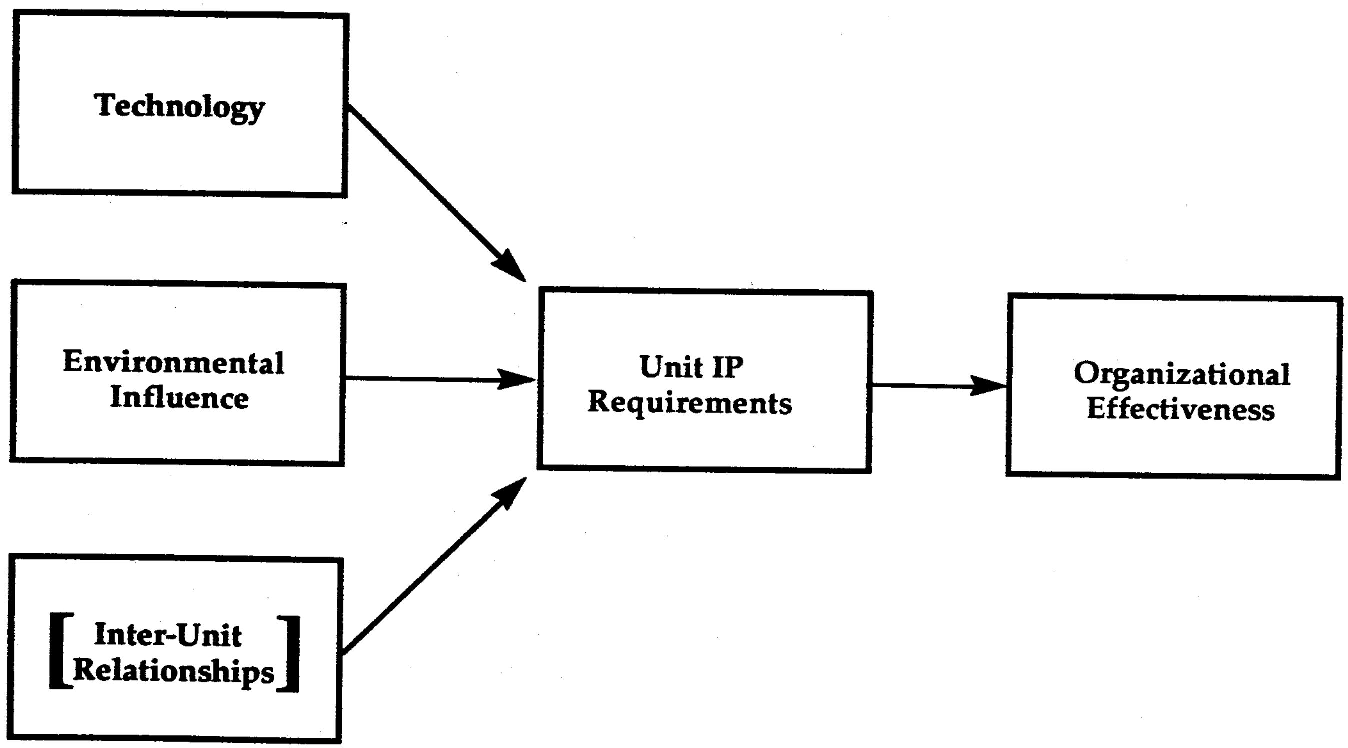
The IP model views the fit between information capabilities and requirements to be influenced by contextual variables of organizational design. Kraemer and Pinsonneault (1990) define contextual variables as those factors relevant to the closer environment of the workers as opposed to broader, organizational environments. Variables such as level and amount of technology and various environmental conditions are believed to have significant bearing upon overall effectiveness (Ford & Slocum, 1977). See Figure 2–2 for an illustration of these contextual variables.

According to the information processing model, uncertainty and equivocality (to be explained in detail in Sections 2.3.1 and 2.3.2 below), need to be resolved if the workers are to be effective. Building upon the Tushman and Nadler model, Daft and Lengel (1986) also proposed that effectiveness is a function of fit between information processing requirements and capabilities in their model of information processing illustrated in Figure 2–3. Daft and Lengel suggested that using the appropriate media with respect to levels of information quantity (explained in Section 2.5.1) and information richness (explained in Section 2.5.2) can help to reduce uncertainty and equivocality.

This research used variables from the IP model to operationalize and test communication media in aerospace information processing. The

Figure 2–2

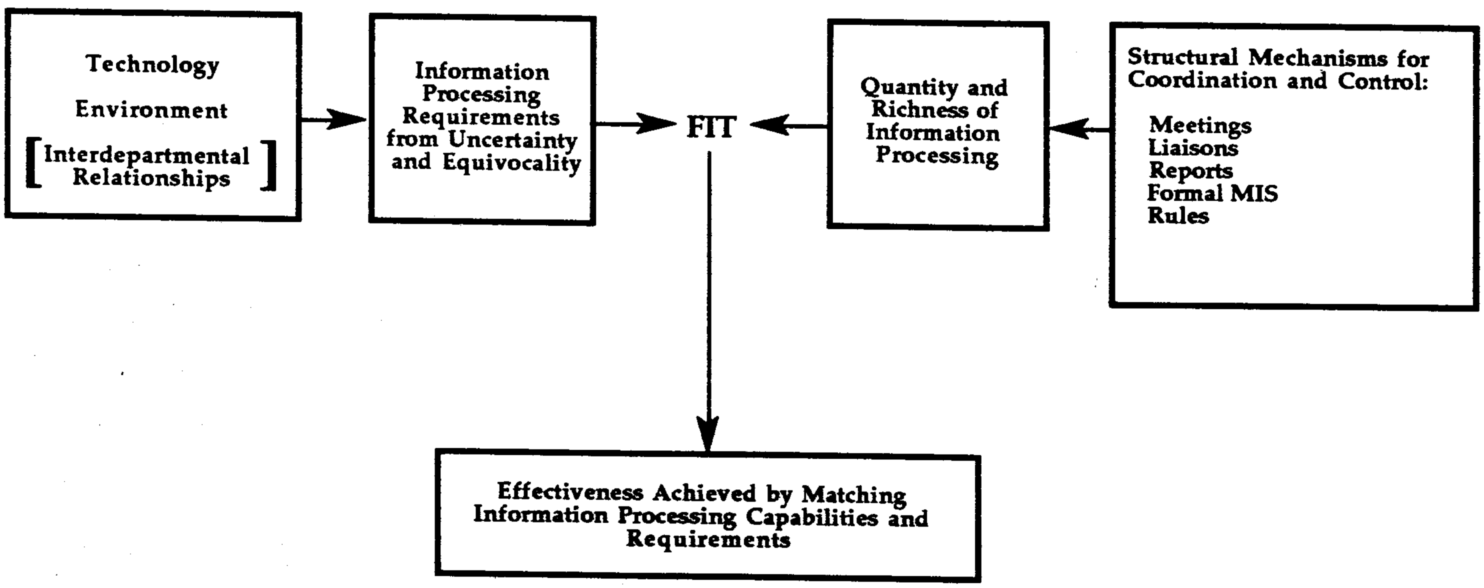
Basic Contextual Variables*
(Based on Balaguer 1988)



*Bracketed variables not used in hypothesis testing

Figure 2–3

Daft and Lengel Framework Summary Model of Information Processing and Organizational Design* (1986)



*Bracketed variables not used in hypothesis testing

theoretical model that guided the research, illustrated in Figure 2–4, is drawn from extensions offered by Leifer and Triscari (1987) and Balaguer (1988) to the Tushman and Nadler (1978) and Daft and Lengel (1986) IP models.

2.3 Information Processing (IP) Requirements

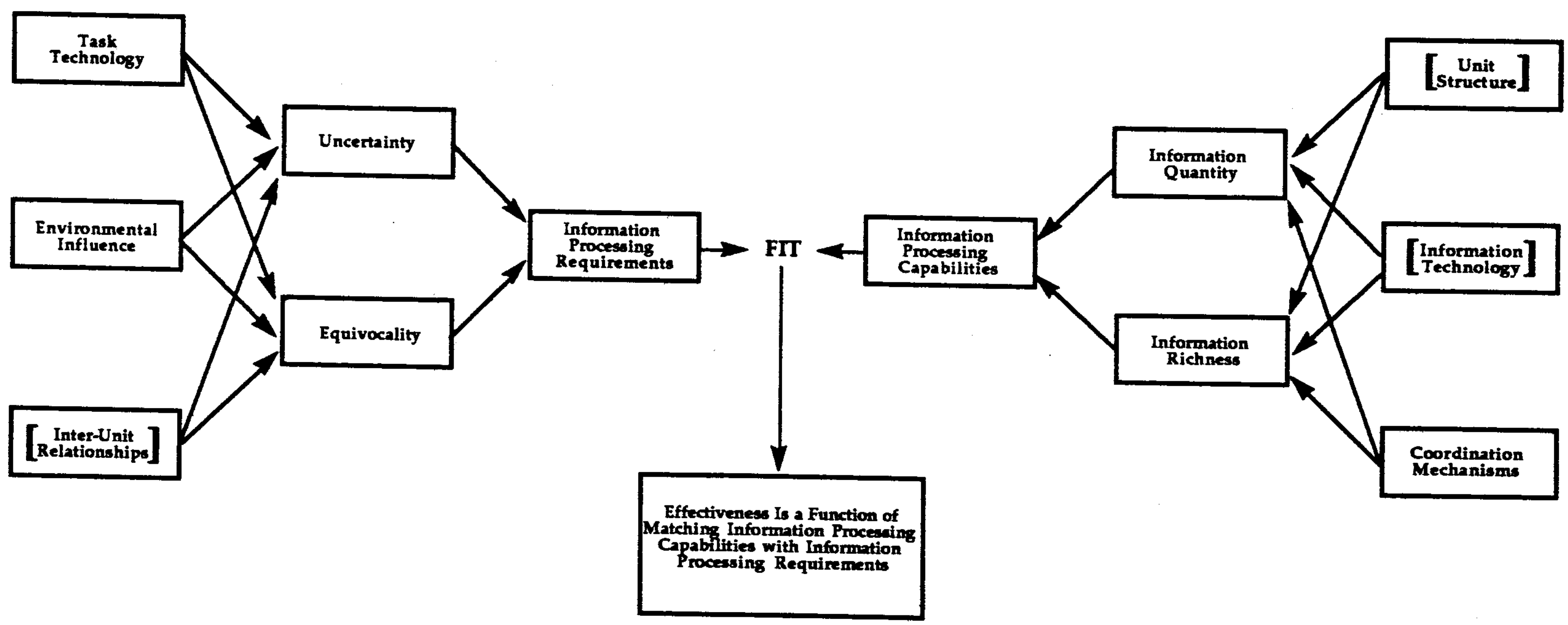
As stated above, the IP model developed by the "School of Fit" (Balaguer, 1988; Daft & Lengel, 1986; Leifer & Triscari, 1987; Tushman & Nadler, 1978) views effectiveness as a function of fit between information processing requirements and capabilities. To look at this hypothesized relationship more closely, this section explains the essential variables of information processing requirements.

2.3.1 Uncertainty

In the literature, uncertainty has been defined in a variety of ways. Drawing upon the work of Burns and Stalker (1961) and Woodward (1965), Galbraith (1973) defined uncertainty as a difference that exists between how much information is required to perform a task and the amount of information that the workers actually possess. Theoretically, as the organizational complexity increases, workers' abilities to make precise, significant statements about functioning diminishes (Cravens, 1970; Daft & Wiginton, 1979). Consequently, in order to overcome imprecision associated with uncertain environments, individuals will need to process more objective information (Balaguer, 1988; Blandin & Brown, 1977), and

Figure 2-4

Leifer and Triscari Revised Information Processing (IP) Model (1987)



*Bracketed variables not used in hypothesis testing

with higher levels of uncertainty, written and oral communications will tend to increase (Drazin & Van de Ven, 1985).

Lawrence and Lorsch (1967) defined uncertainty as a function of managerial perspective, and related it to three factors:

1) lack of interpretable information;
2) confusion regarding causal relationships; and,
3) variable lengths of time to obtain feedback concerning the results of actions.

Similar to Lawrence and Lorsch's work, Duncan (1972) found that:

1) environments represent potential sources for uncertainty;
2) clarity of information and perceived certainty of cause and effect have a temporal dimension; and,
3) uncertainty about procedures and methods increases as environments become more complex.

Some of the common elements among these tenets involve adequacy of available information, individual decision-making, and factors in the work environments. Drawing upon previous work by Balaguer (1988) and Downey, Hellriegel, and Slocum (1975), measures of uncertainty in this research are defined with respect to three areas:

1) extent to which there is adequate information to make good decisions;
2) extent to which decisions affect overall performance;
3) extent to which job-related activities are clearly defined.

One of the characteristics of uncertainty is that its variable "space" is fairly well defined. In uncertain environments, more or less explicit

questions can be posed to elicit information that is located somewhere among the organizational members, and it involves a process of finding the needed information. For example, if an R&D engineer wanted to know which of two turbines was selected after a bidding process, that would be a situation involving uncertainty.

One of the goals of this study was to obtain data on levels of uncertainty in the aerospace environment. To do this, the survey instrument posed a series of four questions that targeted the relevant areas specified above. The questions themselves are provided in Part 4, Methods.

2.3.2 Equivocality

The presence of equivocality implies an unclear domain caused by ambiguity or the existence of multiple and conflicting interpretations resulting in confusion and lack of understanding (Daft & Lengel, 1986; Daft & Macintosh, 1981; Weick, 1979). It differs from uncertainty in that the variable "space" of equivocal issues is unclear. That is, specific questions to address problems are difficult to pose, and explicit answers to such questions are not easily forthcoming. For example: knowing how to counter the entrance of a new competitor in a field that once had no competitors would qualify as a problem involving equivocality. With no specific, objective information available that explains how to react to the emergence of a new competitor, it is not a problem of uncertainty (which implies that there exists a specific answer to the question). Instead, differing views must be exchanged to interpret the situation and enable

participants to plan their future activities. Equivocality may be reduced through the exchange of differing views to define problems and resolve conflict through participation in shared interpretation to influence future activities (Daft & Lengel, 1986; Tyler, Bettenhausen, & Daft, 1989).

According to IP theory, lessening the amount of equivocality demands ambiguity-reduction communications best served by information-rich, face-to-face conversations. Information richness is defined in greater detail in Section 2.5.2, but basically richness is the ability of information to change understanding within a time interval; that is, communications that overcome frames of reference or clarify ambiguity in a timely manner are defined as rich by Daft and Lengel (1986).

2.3.3 Summary of Uncertainty and Equivocality

The theory underlying this research postulates that lack of information can be viewed in two ways. First, uncertainty implies the absence of factual answers for questions (Daft, Lengel, & Trevino, 1987; Galbraith, 1973). Employees respond to uncertainty by seeking relevant information to answer the obvious question(s) at hand. The assumptions are, of course, that the questions can be posed and also that specific, concrete answers can be provided. Secondly, there are organizational environments that are characterized by a lack of knowledge coupled with a general absence of precise questions to arrive at the solutions. The formulation of questions to be asked and the consequent construction of answers to these questions imply the presence of equivocality (Daft & Weick, 1984; Weick, 1979).

Both of these elements have been combined by Daft and Lengel (1986) into a hypothesized, integrating framework of equivocality and uncertainty involving information processing requirements. The proposition is that both of these forces are similar to an n-dimensional information space (Baligh & Burton, 1981; Marschak & Radner, 1972). Uncertainty is "a measure of the organization's ignorance of a value for a variable in the space" while equivocality is "a measure of the organization's ignorance of whether a variable exists in the space" (Daft & Lengel, 1986, p. 557).

Figure 2–5 illustrates uncertainty and equivocality as independent constructs. Represented on the horizontal axis, the levels of uncertainty vary depending upon the requirements to process information to answer a variety of explicit questions to solve known problems. As represented on the vertical axis, the levels of equivocality vary depending upon the extent to which the employees can define problems, clarify ambiguities, exchange viewpoints, and reach common accord. The four cells or quadrants of the illustration depict theoretical categories that may help to explain both the quantity and the form of the information processing in an organization.

In Cell 1 (high equivocality; low uncertainty), answers to equivocality are defined as those obtained through shared, subjective opinions rather than from objective data. Members in this environment encounter situations where the questions to be asked or the problems to be solved may not be readily apparent. The IP model postulates that individuals will tend to rely on judgment and experience to interpret the events and exchange points of view to enact a common perception.

Figure 2–5

Daft and Lengel Framework of Equivocality and Uncertainty on Information Processing Requirements (1986)

EQUIVOCALITY	UNCERTAINTY: Low	UNCERTAINTY: High
High	1. HIGH EQUIVOCALITY LOW UNCERTAINTY (MEDIUM I/P REQUIREMENTS) Occasional ambiguous, unclear events; managers define questions, develop common grammar, gather opinions.	2. HIGH EQUIVOCALITY HIGH UNCERTAINTY (HIGH I/P REQUIREMENTS) Many ambiguous, unclear events; managers define questions, also seek answers, gather objective data and exchange opinions.
Low	3. LOW EQUIVOCALITY LOW UNCERTAINTY (LOW I/P REQUIREMENTS) Clear, well-defined situation; managers need few answers, gather routine, objective data.	4. LOW EQUIVOCALITY HIGH UNCERTAINTY (MEDIUM I/P REQUIREMENTS) Many well-defined problems; managers ask many questions, seek explicit answers, gather new, quantitative data.

Through their interchange of information, the members seek to evolve common grammar and perspectives necessary to develop a collective judgment to reduce equivocality; that is, equivocal situations, by definition, have no objective answers.

Cell 4 (low equivocality; high uncertainty) is the reverse situation of Cell 1 described in the preceding paragraph. In Cell 4, while equivocality is relatively low, uncertainty is high due to the presence of many explicit, well-defined questions. Although the members of this environment know what questions to ask, they need additional concrete information about various issues and problems. The information processing in these cases often represents systematic acquisition and analysis to answer important questions. A large number of explicit questions that are answerable with specific information somewhere in the organization is defined as high uncertainty.

Cell 2 represents high levels of both uncertainty and equivocality with consequent high information processing requirements. It is characterized by an environment where there is a multiplicity of poorly understood issues and possible disagreement over what is to be done. It requires subjective experiences, discussion, judgment, and purposive enactment. Likewise, there will also tend to be a sizable number of questions that are amenable to answering with appropriate acquisition of explicit information. The specific information used to reduce the uncertainty may also contribute to interpretation of other more equivocal issues. Daft and Weick (1984) proposed that such an environment is fostered by various influences, such as rapid changes, unpredictable

shocks, and an unanalyzable technology (this technology is described in Section 2.4.3).

Cell 3 (low uncertainty; low equivocality) calls for the least amount of information processing. Because the issues are well understood, there is a reduced need for exchange of subjective experiences among the members. Also, relatively well-defined situations and few new problems call for low amounts of additional data. Largely governed by a routine and stable environment, this quadrant relies mainly upon standard operating rules and procedures, reports, and statistical data.

2.4 Contextual Variables of Information Processing (IP) Requirements

Information processing is defined as the volume or quantity of data about organizational activities that is gathered and interpreted by organization participants (Daft & Macintosh, 1981). In the performance of their activities, organizations process information to reduce inhibitors to their effectiveness (Hiltz & Turoff, 1978). To the extent that Perrow (1967) was correct in his judgment that technology is the defining characteristic of an organizational system, it is important to examine the setting wherein technology functions and enables the coordination and control of work.

Technology has been variously defined. Dubin (1959), claiming technology to be the most essential determinant of occupational behavior, divided the concept into two elements: first, he saw it as the tools, instruments, machines, and formulae necessary to perform tasks, and

secondly, he viewed it as the ideas embodying the goals of work, the functional importance, and the rationale of methods used. Woodward (1965) characterized technology as who does what with whom, when, where, and how often. Perhaps Daft and Lengel (1986) summarized it best when they defined technology as the knowledge, tools, and techniques used to transform inputs into organizational outputs. The essential element emerging from each of these positions is that technology somehow involves a transformation process whereby physical and cognitive efforts change inputs into outputs (Miller & Rice, 1967). As such, it would appear that virtually any group or organization relies upon technology to some degree to accomplish its tasks and achieve its goals. And, as organizations become more diversified and increase their levels of technological complexity, the volume of communication tends to increase (Hage, Aiken, & Marrett, 1971). Hence, communication and organizational structures are closely linked, and communication plays an essential role in making human behavior more efficient (Daft & Macintosh, 1981; Drazin & Van de Ven, 1985; Szilagyi & Wallace, 1987).

2.4.1 Task Technology

As suggested by Galbraith (1973) and Thompson (1967), increases in the amounts of task uncertainty serve to increase the quantity of information that organizational members must process in the orderly production of work. According to Perrow (1967), two dimensions that affect the transformation of inputs into outputs are variety and analyzability.

2.4.2 Variety

Variety is defined as the measure of unique or unanticipated events or situations that workers routinely encounter. Low degrees of variety indicate that problems tend to be few in number, repetitive, and often easy to anticipate ahead of time. High variety implies that there are frequently new problems occurring that require novel approaches in order to eliminate them: that is, it is difficult if not impossible to predict problematic situations in advance. Formalized sets of rules and procedures written to govern foreseeable problems tend not to exist for the simple reason that problems are neither recurrent nor predictable.

2.4.3 Analyzability

The other dimension, analyzability, is somewhat related to variety. To the extent that problems may be anticipated, solutions may also be planned to cope with the problems when they do occur. Low analyzability means that production methods and/or problems may not be readily amenable to careful scrutiny to provide formal procedures to deal with problems when they do occur. High analyzability refers to a high capacity to provide procedural methods to solve difficulties.

In a revised model of information processing, Daft and Lengel (1986) drew upon Daft's earlier model that he had proposed with Macintosh (1981) to examine the relationship between task analyzability and variety. The Daft and Lengel (1986) study determined that support systems should reflect the work-unit requirements of the organization.

Specifically, they sought to identify the relative amounts of data-processing activity and equivocality as represented in a two by two matrix. As task variety increases, effort appears to be directed toward information processing and away from more direct, production-related activities. As tasks become less analyzable (lack of analyzability implies greater difficulty in formulating standard measures to apply to problems), equivocality tends to increase. When individuals are faced with unanalyzable situations, they are more likely to use information-rich media (Blandin & Brown, 1977; Randolph & Finch, 1977; Rice, 1992b; Tushman & Nadler, 1978; Van de Ven, Delbecq, & Koenig, 1976; Zmud, Lind, & Young, 1990). The theory for using various communication strategies is summarized in Figure 2–6.

Obviously, task technology will vary from organization to organization. Craft technology is typified by few exceptions and tasks that are difficult to fully analyze. Routine technology is also characterized by few exceptions, but in this case the tasks are usually analyzable whereas nonroutine technology has both large numbers of exceptions as well as tasks that are difficult to analyze. Lastly, engineering technology has many exceptions but its processes are generally analyzable.

2.5 Organizational Design Variables of Information Processing (IP) Capabilities

Becker and Baloff (1969) assert that an organization's structure affects its problem-solving capacity. Effective information processing allows the organization to reduce ineffectiveness due to uncertainty or

Figure 2–6

Daft and Lengel Relationship Matrix of Technology with Structure and Information Required for Task Accomplishment (1986)

ANALYZABILITY	Low (VARIETY)	High (VARIETY)
Unanalyzable (Low)	1. Unanalyzable, Low Variety (Craft Technology) Structure: a. Rich media to resolve unanalyzable issues b. Small amount of information Examples: Occasional face-to-face and scheduled meetings, planning, telephone.	2. Unanalyzable, High Variety (Nonroutine Technology) Structure: a. Rich media to resolve unanalyzable issues b. Large amount of information to handle exceptions Examples: Frequent face-to-face and group meetings, unscheduled meetings, special studies and reports.
Analyzable (High)	3. Analyzable, Low Variety (Routine Technology) Structure: a. Media of low richness b. Small amount of information Examples: Rules, standard procedures, standard information system reports, memos, bulletins.	4. Analyzable, High Variety (Engineering Technology) Structure: a. Media of low richness b. Large amount of information to handle frequent exceptions. Examples: Quantitative data bases, plans, schedules, statistical reports, a few meetings.

equivocality or a combination of the two (Leifer & Triscari, 1987). Zmud (1990) argues that technology alone does not necessarily alter information behavior. Rather, information behavior varies in organizations due to the combination of variables other than the technologies themselves. Specifically, the coordination mechanisms influence an organization's capability to process information (Balaguer, 1988).

2.5.1 Information Quantity

Quantity of information is synonymous with volume, amount, or as indicated in some studies, bandwidth (Shannon & Weaver, 1963). Increased demands with respect to uncertainty and equivocality affect quantity in that greater amounts of information must be exchanged to provide the factual answers required by uncertainty and the more complex negotiations to reduce equivocality. As stated by Tushman and Nadler (1978, pp. 616–617):

> Where the nature of the subunit's work is highly certain, small amounts of information are sufficient—perhaps in the form of fixed standards, formal operating procedure, or rules. Little new information or information processing are required for task performance. Thus, the need for continual monitoring, feedback, and adjustment is minimal, and the information processing requirements for the subunit are relatively small. Where the nature of the unit's work is highly uncertain, need for the constant flow of information increases among role occupants. . . . [and] the greater the uncertainty faced by a set of subunits, the greater are the

information processing requirements for the whole organizational structure.

2.5.2 Information Richness

Information richness or media richness was defined by Daft and Lengel (1984, 1986) as the degree to which information can alter individuals' understandings of problems to be solved or issues to be negotiated in a given time period. They proposed that higher levels of information richness allow more signs to impact the interpretation of messages in less time. That is, rich media tend to convey more social context cues such as body language or tone of voice (e.g., face-to-face conversations) than do non-rich media (e.g., typewritten memos or notes). Other determinants of richness are proposed to include a medium's capacity for immediate feedback, number of senses and cues involved, personalization, and language variety that includes nicknames and code words.

Daft, Lengel, and Trevino (1987) offered the empirical evidence that communication channels are disparate in their capacity to carry various information context cues. In their research they found that managers preferred using rich media when situations were high in ambiguity, and managers used less-rich media in unequivocal situations. Furthermore, they showed that the high-performing managers were more likely to use rich media in ambiguous situations than were low-performing managers.

Markus (1988) used roughly the same criteria as Daft, Lengel, and Trevino (1987) in a study of nearly 500 managers and found similar

correspondence between empirical rankings of media and the theoretically expected rankings. Zmud, Lind, and Young (1990) conducted an empirical study of 14 communication channels within a Fortune 500 company. Their results also confirmed Daft and Lengel's (1984, 1986) proposition that interpersonal, verbal media emerged as being more rich than impersonal, written channels. Lind and Zmud's (1991) study of a large, multinational firm showed empirically that richness of communication media influenced convergence—the degree of mutual understanding—between technical providers and the other business personnel in the firm's activities. This convergence influenced technological innovation, and the authors stated that information richness was a predictor of the convergence more than any other variable, such as communication frequency. Rice (1992) found conceptual support for richness theory in an empirical study of various types of communication media, including electronic mail and voice mail, among others.

Information processing theory holds that equivocality resolution requires an exchange of differing views to define problems and resolve conflict, and theorizes that information-rich communication strategies contribute more effectively to resolving equivocality due to the increased possibilities for shared interpretation (Daft & Lengel, 1986; Tyler, et al., 1989). Media of lower richness offer fewer variables for understanding and tend to be less effective in reducing ambiguity or equivocality (Lind & Zmud, 1991).

A dimension of information richness associated with various types of communication media in seven empirical studies was described by Rice

(1992) and is summarized in Table 2–1. It should be noted that all of the studies which considered CMC mechanisms such as electronic mail placed CMC below face-to-face and telephone interactions with respect to richness.

A review of the literature over several years presents numerous other scholars who argue that CMC is not a rich communication medium. For example, Kraut, Lewis, and Swezey (1982) stated that the lack of social feedback and unpredictability of the style of messages make CMC a difficult medium to understand. Bikson and Gutek (1983) found that CMC carried fewer social nuances and as a result was considered less satisfying. The research studies of both Scheirer and Carver (1977) and Diener, Lusk, DeFour, and Flax (1980) noted depersonalization effects of advanced technologies on users. Kiesler, Siegel, and McGuire (1984) observed that CMC offers few shared norms for structuring messages, both formal and informal. They found that CMC was an inefficient mechanism and that CMC groups took longer to reach consensus than did face-to-face groups (p. 1128) and had to exert more effort in order to be understood (p. 1130). They found that CMC is more "depersonalized," and in addition to exhibiting more uninhibited behavior, the medium seemed to permit less control over a dominant person. Also, they believed that CMC is lean with respect to organizational vertical hierarchy and status identification: "[CMC conveys] none of the nonverbal cues of personal conversation . . . that provide social feedback and may inhibit extreme behavior (p. 1130)."

Spitzer (1986, p. 20) stated that CMC is "a form of writing lacking nonverbal cues." He pointed out that use of the keyboard is often utilized

Table 2–1

EMPIRICAL RANKINGS OF COMMUNICATION MEDIA
BY INFORMATION RICHNESS* (Based on Rice, 1992)

Medium	Study A	B	C	D	E	F	G
Face-to-face	1.00	4.4	4.4	.81	4.6		100.0
Video	—	—	—	.24	—	—	—
Telephone	.94	3.8	3.8	-.52	4.3	4.5	85.9
Group meeting	.65	—	—	—	4.1	—	—
Voice messaging	.63	—	—	—	3.7	3.5	—
Group gathering	.59	—	—	—	—	—	—
Computer report	.47	2.5	1.1	—	—	—	—
Document/report	.27	3.3	3.2	—	—	—	48.2
Memos	—	3.6	3.5	—	—	—	54.0
Electronic mail	.13	3.5	2.8	—	—	—	75.3
Facsimile	.11	—	—	—	—	—	—
Handwritten note	.11	—	—	—	—	—	64.4
Letter/message	.00	—	—	-.85	3.5	3.7	67.1

*Study sources and criteria for scales provided on the following page.

Table 2–1, Continued

Sources, Criteria, and Scales for Empirical Rankings of Media by Information Richness

Study A:	(Zmud, Lind, & Young, 1990). Criteria: 14 items representing accessibility, information quality, cue variety, and feedback, for lateral communication. Values are dimensional scaling scores, normalized to 0.0-1.0. Scale: seven-point MDS comparisons derived from the two MDS dimensions (quality and feedback) for lateral communication. $N = 158$
Study B:	(Schmitz & Fulk, 1990). Criteria: mean of 4 items measuring timely feedback, nonverbal cues, tailored messages, and rich/varied language. Scale: 1=not at all rich to 5=extremely rich. $N = 491$
Study C:	(Fulk & Ryu, 1990). Same criteria and scale as for Study B. $N = 58$
Study D:	(Short, Williams, & Christie, 1976). Criteria: semantic differential items such as warmth, personalness. $N = 71$
Study E:	(Rice, 1992). Criteria: mean of perceived appropriateness of using various media for 10 communication activities: exchanging information, bargaining and negotiating, getting to know someone, asking questions, staying in touch, exchanging time-sensitive information, generating ideas, resolving disagreements, making decisions, and exchanging confidential information. Scale: 1=appropriate to 5=inappropriate, reverse scored to make direction of ranking comparable to other studies. $N = 159$
Study F:	(Rice, 1992). Criteria and scale: same as for Study E. $N = 240$
Study G:	(Trevino, Lengel, & Bodensteiner, 1990). Criteria: overall assessment of medium's capacity for timely feedback, nonverbal cues, tailored messages, rich/varied language. Scale: rating of media 1 - 100. $N = 40$

by individuals to represent graphically (e.g., spelling out the word "grin" to emphasize a tongue-in-cheek comment) the affective communication information missing in CMC communication. In that same year, Sproull and Kiesler (1986) in their research of electronic mail in organizations also found that CMC reduced context cues. Schmitz and Fulk (1991), in their study of social influences and new media involving 511 employees of a high-tech petrochemical firm, classified various media with respect to information richness. Their descriptive statistics placed CMC as less rich than face-to-face communication, telephone conversations, and personal written text. They found only formal written and numeric texts to be less rich than CMC.

2.5.3 Summary of Information Quantity and Richness

Evidence suggests that the dimensions of information quantity and information richness separately or together influence information processing capability (Balaguer, 1988; Daft & Lengel, 1986; Daft, Lengel, & Trevino, 1987; Lind & Zmud, 1991; Rice, 1992; Tyler, Bettenhausen, & Daft, 1989). Questions of uncertainty require objective answers; therefore, the IP model states that questions requiring definite answers that are possessed by some person or are located in records within are best resolved by using lean information media. The model further indicates that questions which require developing a common grammar to formulate questions and strategies to achieve effectiveness—involving reduction of equivocal issues—are best served by information-rich, face-to-face communication exchanges. Lastly, the consensus of the empirical literature over several

years indicates that with respect to media richness, text-based exchanges such as CMC are ranked below face-to-face and telephone communication.

2.5.4 Coordination Mechanisms and Media Components

The principal coordination mechanisms drawn from structural characteristics for reducing equivocality or uncertainty were described by Daft and Lengel (1986) as a seven-part continuum:

1) rules and regulations;
2) formal information systems;
3) special reports;
4) planning;
5) direct contact;
6) integrators (assigned to a boundary-spanning activity within the organization); and,
7) group meetings.

The first mechanism, rules and regulations, implies a formalistic, top-down type of communication that is most often used in response to routine procedures with little equivocality present. Because it is the leanest (i.e., least rich as previously described) of the mechanisms, it is also the weakest if applied to situations that are unanalyzable or have high degrees of variety.

The second mechanism, formal information systems, also refers to a lean medium that is typified by printed materials such as computer reports, statistical data, budgetary statements, or credit defaults (Daft & Macintosh, 1981). While it is possible that differences in interpretation of

the data may arise, this mechanism is mainly useful as a tool to reduce uncertainty about well understood and quantifiable issues (Balaguer, 1988).

The third type, formal reports, is very similar to the second in that both provide relatively objective information to be used by managers to reduce problems involving uncertainty (Daft & Lengel, 1986).

The fourth and middle mechanism, planning, spans the two dimensions of uncertainty and equivocality. As organizational members come together initially to define goal and set objectives, equivocality tends to be high due to the necessity of finding a common grammar and reaching accord on the issues to be addressed. Later in the planning process, however, equivocality gives way to matters of uncertainty that are more efficiently handled by the first three mechanisms discussed above.

The fifth, direct contact, represents the most basic levels of personal information processing with both vertical and horizontal exchanges between organizational members. The richer aspects of communication such as face-to-face conversation are often accompanied by interchanges of the non-rich type, such as the use of formal reports and memos.

The sixth mechanism, the use of integrators, involves assigning organizational members to span the boundaries between departments or units (Leifer & Huber, 1977). While the role of an integrator may involve only the transmission of data to reduce uncertainty, it is often common that integrators are used to help reduce disagreement. Hence, strategies are sometimes called into play in order to solve equivocal issues that have arisen between organizational units (Lawrence & Lorsch, 1967a).

The last mechanism, the group meeting, is mainly oriented toward resolving problems of equivocality. The meetings themselves may involve committees, task forces, or teams. Mainly face-to-face, the meetings are high in information richness to overcome subjective problems.

The coordination mechanisms are not intended to equal communication media, per se, but rather they typify strategies by which people can communicate and exchange information. The media themselves that are used to receive and distribute information can be specified as variables in the model (Daft & Huber, 1987; Daft, et al., 1987; Tyler, et al., 1989). Because uncertainty and equivocality in this model imply that there are two types of information needs, it suggests that the members of an organization will adopt different strategies to suit the communication tasks within the contextual variables of variety and analyzability previously described.

The lower numbered strategies are hypothesized to be best-suited for reducing uncertainty, and as one progresses from one down the continuum to seven, they become increasingly information-rich, and better-suited to reducing equivocality. However, movement down the continuum can become increasingly costly to the organization with respect to investments in time and commitment. The most cost-effective strategy, therefore, is to use the lowest-numbered mode that will reduce the perceived uncertainty or equivocality.

The Daft and Lengel (1986) structural characteristics were seminal components in the development of the IP model, and as such warrant the

description provided above. However, for the purposes of this research, the focus here is on various forms of media use, and these media are operationalized as:

1) formal written reports;
2) all other written documents (e.g., letters, memos, notes);
3) electronic mail;
4) telephone voice mail;
5) telephone conversations;
6) one-on-one, face-to-face conversations;
7) liaisons (talking to people who act as formal representatives of others);
8) meetings (speaking face-to-face with two or more persons.

2.6 Summary of the Research Framework

While suggesting that effectiveness is contingent upon the degree of fit between an organization's information processing requirements and capabilities, some contemporary design theorists (Daft & Lengel, 1984; Daft & Lengel, 1986; Galbraith, 1973; Tushman & Nadler, 1978) originally offered a modicum of empirical research to support the claim (Balaguer, 1988). The model they have proposed, however, appears to have sufficient content validity to merit further investigation. An essential aspect of this research consists in analyzing the processes by which persons involved in STI transfer are linked within the macro-network of their environments.

This dissertation concurs with the position that unprecedented growth in communication involving the use of computers and electronic

media has increased information processing activities in many new and not yet fully understood ways (Hiltz & Turoff, 1978, Chapter 8; Siegel, Dubrovsky, Kiesler, & McGuire, 1986, p. 1123). It is therefore incumbent upon researchers to investigate the potential that CMC technology offers when used as a work-related communication strategy (Applegate, Cash, & Mills, 1988; Danowski & Edison-Swift, 1985; Davis, Bagozzi, & Warshaw, 1989; Hjalmarsson, Oestreicher, & Waern, 1989; Hurt & Hibbard, 1989; Pinelli, Kennedy, & Barclay, 1994; Piturro, 1989; Rice, 1992a), and it is toward that objective that this project was undertaken.

The preceding review of the literature explains the IP model's position that overall effectiveness in job performance is a function of the fit between information processing requirements and information processing capabilities. It also describes the rationale for adopting an information processing approach to investigate the communication processes of organizational task orientations, that is, developing and sharing information (STI) as a necessary commodity in the U.S. aerospace environment.

REFERENCES CITED IN PART 2

Allen, T. J., & Hauptman, O. (1987). The influence of communication technology on organizational structure. Communication Research, 14, 575–587.

Applegate, L. M., Cash, J. I., & Mills, D. Q. (1988). Information technology and tomorrow's manager. Harvard Business Review, 88, 128–136.

Balaguer, N. S. (1988). CIM information technology utilization and organizational design: A field study on information processing. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Baligh, N. M., & Burton, R. M. (1981). Describing and designing organization structure and processes. International Journal of Policy Analysis and Information Systems, 5, 251–266.

Becker, S. W., & Baloff, N. (1969). Organization structure and complex problem solving. Administrative Science Quarterly, 14, 260–271.

Bikson, T. K., & Gutek, B. A. (1983). Advanced office systems: An empirical look at utilization and satisfaction (No. N–197–NSF). Rand.

Blandin, J. S., & Brown, W. B. (1977). Uncertainty and management's search for information. IEEE transactions on Engineering Management, EM–24, 114–119.

Burns, T., & Stalker, G. M. (1961). The management of innovation. London: Tavistock.

Cravens, D. W. (1970). An exploratory analysis of individual information processing. Management Science(16), B656–670.

Daft, R. L., & Huber, G. P. (1987). How organizations learn: A communication framework. Research in the Sociology of Organizations, 5, 1–36.

Daft, R. L., & Lengel, R. H. (1984). Information richness: A new approach to managerial behavior and organization design. In B. M. Straw & L. L. Cummings (Eds.), Research in organizational behavior (pp. 191–233). Greenwich, CT: JAI Press.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. Management Science, 32, 554–571.

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection, and manager performance: Implications for information systems. Management Information Systems Quarterly, 11, 355–366.

Daft, R. L., & Macintosh, N. B. (1981). A tentative exploration into the amount and equivocality of information processing in organizational work units. Administrative Science Quarterly, 26, 207–224.

Daft, R. L., & Weick, K. E. (1984). Toward a model of organizations as interpretation systems. Academy of Management Review, 9, 284–295.

Daft, R. L., & Wiginton, J. C. (1979). Language and organization. Academy of Management Review, 4, 179–191.

Danowski, J. A., & Edison-Swift, P. (1985). Crisis effects on intraorganizational computer-based information. Communication Research, 12, 251–270.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. Management Science, 35, 982–1003.

Diener, E., Lusk, R., DeFour, D., & Flax, R. (1980). Deindividuation: Effects of group size, density, number of observers, and group member similarity on self-consciousness and disinhibited behavior. Journal of Personality and Social Psychology, 39, 449–459.

Downey, H. K., Hellriegel, D., & Slocum, J. R., Jr. (1975). Environmental uncertainty: The construct and the application. Administrative Science Quarterly, 20, 613–629.

Drazin, R., & Van de Ven, A. H. (1985). Alternative forms of fit in contingency theory. Administrative Science Quarterly, 30, 514–539.

Dubin, R. (1959). The sociology of industrial relations. Englewood Cliffs, NJ: Prentice-Hall.

Duncan, R. B. (1972). Characteristics of organizational environments and perceived uncertainty. Administrative Science Quarterly, 17, 313–327.

Ford, J. D., & Slocum, J. W. (1977). Size, technology, environment and the structure of organizations. Academy of Management Review, 2, 561–575.

Galbraith, J. R. (1973). Designing complex organizations. Reading, MA: Addison-Wesley.

Hage, J., Aiken, M., & Marrett, C. B. (1971). Organization structure and communications. American Sociological Review, 36, 860–871.

Hiltz, S. R., & Turoff, M. (1978). The network nation: Human communication via computer. Reading, MA: Addison-Wesley.

Hjalmarsson, A., Oestreicher, L., & Waern, Y. (1989). Human factors in electronic mail system design. Behaviour & Information Technology, 8, 461–474.

Hurt, H. T., & Hibbard, R. (1989). The systematic measurement of the perceived characteristics of information technologies I: Microcomputers as innovations. Communication Quarterly, 37, 214–222.

Kiesler, S., Siegel, J., & McGuire, T. W. (1984). Social psychological aspects of computer-mediated communication. American Psychologist, 39, 1123–1134.

Kraemer, K. L., & Pinsonneault, A. (1990). Technology and groups: Assessment of the empirical research. In J. Galegher, R. Kraut, & C. Egido (Eds.), Intellectual teamwork: Social and technological foundations of cooperative work (pp. 375–405). Hillsdale, NJ: Lawrence Erlbaum.

Kraut, R. E., Lewis, S. H., & Swezey, L. W. (1982). Listener responsiveness and the coordination of conversation. Journal of Personality and Social Psychology, 43, 718–731.

Lawrence, P. R., & Lorsch, J. W. (1967a). Differentiation and integration in complex organizations. Administrative Science Quarterly, 12, 1–47.

Leifer, R., & Huber, G. P. (1977). Relations among perceived environmental uncertainty, organizational structure, and boundary-spanning behavior. Administrative Science Quarterly, 22, 235–247.

Leifer, R., & Triscari, T. (1987). Organizational information processing characteristics and computer based information systems design (Working paper), School of Management, Rensselaer Polytechnic Institute, Troy, NY.

Lind, M. R., & Zmud, R. W. (1991). The influence of a convergence in understanding between technology providers and users on information technology innovativeness. Organization Science, 2(2), 195–217.

Markus, M. L. (1988). Information richness theory, managers, and electronic mail. Academy of Management Proceedings, Anaheim, CA.

Marschak, J., & Radner, R. (1972). Economic theory of teams. New Haven: Yale University Press.

Miller, E. J., & Rice, A. K. (1967). Systems of organizations. London: Tavistock.

Perrow, C. (1967). A framework for the comparative analysis of organizations. American Sociological Review, 32, 194–208.

Pinelli, T. E., Kennedy, J. M., & Barclay, R. O. (1994). Information product use among aerospace engineers and scientists. (Report Number 21). NASA.

Piturro, M. C. (1989). Computer conferencing: Brainstorming across time and space. Management Review, 78, 43–50.

Randolph, W., & Finch, F. (1977). The relationship between organizational technology and the direction and frequency dimensions of task communications. Human Relations, 30, 1131–1145.

Rice, R. E. (1992a). Network analysis and computer-mediated communication systems. In S. W. &. J. Galaskiewicz (Eds.), Communication yearbook (pp. 1–19). Newbury Park, CA: Sage.

Rice, R. E. (1992b). Task analyzability, use of new media, and effectiveness: A multi-site exploration of media richness. Organization Science, 3(4), 475–500.

Rice, R. E., & Love, G. (1987). Electronic emotion: Socioemotional content in a computer-mediated communication network. Communication Research, 14(1), 85–108.

Scheirer, M. F., & Carver, C. S. (1977). Self-focused attention and the experience of emotion: Attraction, repulsion, elation, and depression. Journal of Personality and Social Psychology, 35, 625–636.

Schmitz, J., & Fulk, J. (1990). The role of organizational colleagues in media selection. ICA, Dublin.

Schmitz, J., & Fulk, J. (1991). Organizational colleagues, media richness, and electronic mail: A test of the social influence model of technology use. Communication Research, 18(4), 487-523.

Shannon, C. E., & Weaver, W. (1963). The mathematical theory of communication. Urbana: University of Illinois Press.

Siegel, J., Dubrovsky, V., Kiesler, S., & McGuire, T. (1986). Group processes in computer-mediated communication. Organizational behavior and human decision processes, 37, 157–187.

Spitzer (1986). Writing style in computer conferences. IEEE Transactions on Professional Communication, PC 29(1), 19–22.

Sproull, L., & Kiesler, S. (1986). Reducing social context cues: Electronic mail in organizational communication. Management Science, 32(11), 1492–1512.

Szilagyi, A. D., & Wallace, M. J. (1987). Organizational behavior and performance (4th ed.). Glenview, IL: Scott, Foresman.

Thompson, J. D. (1967). Organizations in action. New York: McGraw-Hill.

Tushman, M. L., & Nadler, D. A. (1978). Information processing as an integrating concept in organizational design. Academy of Management Review, 3, 613–624.

Tyler, B. B., Bettenhausen, K. L., & Daft, R. L. (1989). The use of low and high rich information sources and communication channels in developing and implementing competitive business strategy. Academy of Management Proceedings (pp. 245–249).

Van de Ven, A., Delbecq, A., & Koenig, R. (1976). Determinants of coordination modes within organizations. American Sociological Review, 41, 322–338.

Weick, K. E. (1979). The social psychology of organizing (2nd ed.). Reading, MA: Addison-Wesley.

Woodward, J. (1965). Industrial organization: Theory and practice. London: Oxford University Press.

Zmud, R., Lind, M., & Young, F. (1990). An attribute space for organizational communication channels. Information Systems Research, 1(4), 440–457.

Zmud, R. W. (1990). Opportunities for strategic information manipulation through new information technology. In J. Fulk & C. Steinfield (Eds.), Organizations and communication technology (pp. 95–116). Newbury Park, CA: Sage.

PART 3

HYPOTHESES

3.1 Introduction

This dissertation investigates relationships hypothesized to exist among several variables that influence communication processes. The scope of the study is confined to U.S. aerospace research and development (R&D) scientific and technical information (STI) transfer. In this context, "aerospace" includes aeronautics, space science, space technology, and related fields (Hernon & Pinelli, 1992). Although data on various media types were collected, this dissertation focuses mainly on variables related to computer-mediated communication (CMC). Data collection was funded in part by the NASA/DoD Aerospace Knowledge Diffusion Research Project.

The theoretical approach of this dissertation is based primarily on the Information Processing (IP) model (Balaguer, 1988; Daft & Lengel, 1984, 1986; Daft & Macintosh, 1981; Galbraith, 1974; Leifer & Triscari, 1987; Trevino, Daft, & Lengel, 1990; Triscari, 1984; Tushman & Nadler, 1978). The study examines the technical communication capabilities and information processing requirements of individuals within the contexts of their task environments. It explores whether or not overall effectiveness may be increased by matching information processing requirements and capabilities, as postulated by the IP model.

Specifically, this dissertation analyzes the following variables previously discussed and defined in Part 2:

1) task technology with respect to variety and analyzability;
2) measures of uncertainty;
3) measures of equivocality;
4) communication media and information richness;
5) information processing capabilities;
6) various information technology and coordination mechanisms such as printed documents, electronic networks, telephone voice mail, telephone conversations, face-to-face conversations, liaisons, and group meetings;
7) overall performance and effectiveness of the workers.

A summary of the relationships among these variables postulated by IP theory and discussed in Part 2 is illustrated in Figure 3–1. (Note: bracketed variable names in the IP model illustrated in Figure 3–1 are not used for hypothesis testing in this dissertation.) This chapter presents ten hypotheses to examine the relationships among the relevant variables.

The specific quantitative and qualitative procedures and statistics used to test the hypotheses empirically are explained in Part 4, Methods. The findings of these tests are presented in Part 5, Results. To aid the reader, brief references to the detailed literature review of the variables and concepts discussed in Part 2 are included in this chapter where appropriate.

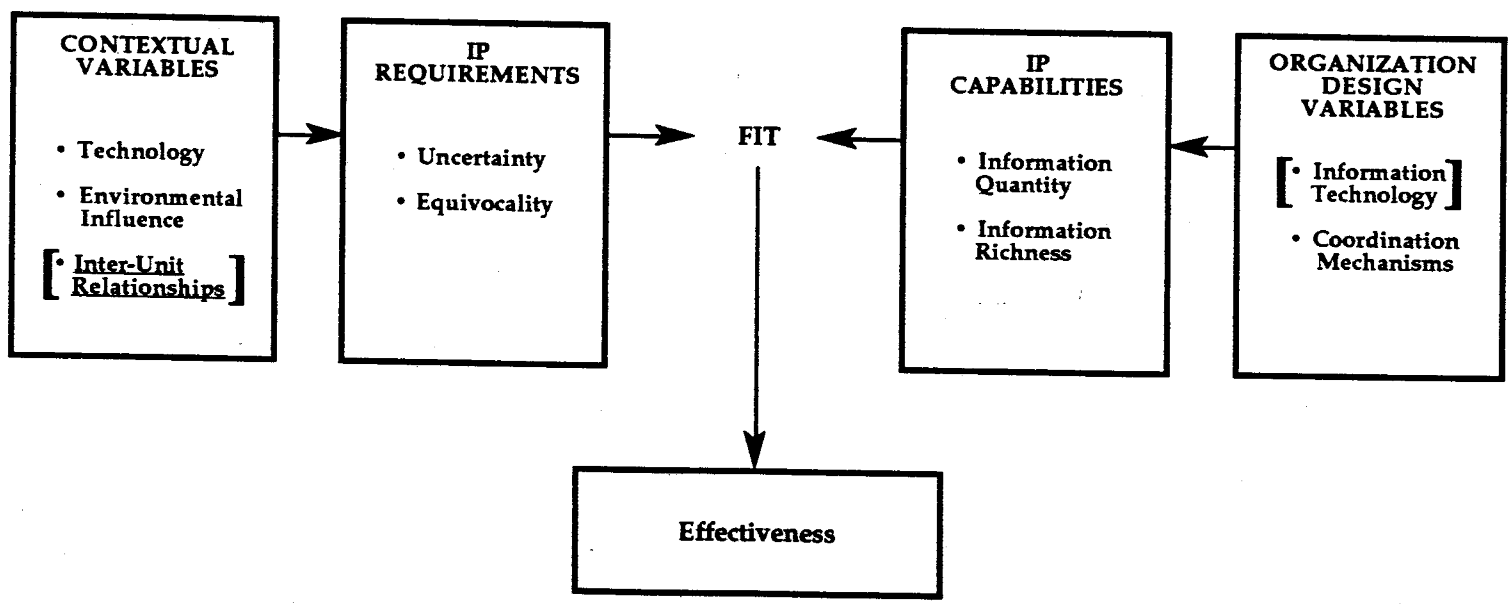
3.2 IP Requirements and Contextual Variables

3.2.1 Introduction

To examine the relationship between tasks and media use, it is important to investigate the work environment. This is accomplished by

Figure 3–1

Proposed Relationships of Variables*
(Based on Balaguer 1988)



*Bracketed variables not used in hypothesis testing

measuring the contextual variables examined in Part 2, that is, the factors relevant to the environment where work is performed, such as degrees of task variety or degrees of analyzability by which problem-solving strategies can be specified in advance (Kraemer & Pinsonneault, 1990). Without an assessment of these dimensions, it would be difficult to assess with confidence the numerous influences affecting communication processes. What this does not imply, however, is that the investigation intends to elaborate on individual tasks of aerospace R&D employees. While other work has addressed some of the more specific functions of the aerospace environment (Pinelli, 1991), a task analysis of an entire national industry would be prohibitive and impractical for the scope and purposes of this study.

However, previous work has been done that aids examination of the more general environmental influences that could be found in various occupational environments, including the personnel who are the subjects in this investigation (Balaguer & Leifer, 1989; Bourgeois, 1985; Dill, 1958; Downey, Hellriegel, & Slocum, 1975; Duncan, 1972, 1973; Ford & Slocum, 1977; Lawrence & Lorsch, 1967; Leifer & Huber, 1977; Triscari, 1984). As adapted from the research literature, this study analyzes the contextual variables of variety and analyzability as one of the steps toward better understanding media use and communication effectiveness.

3.2.2 IP Requirements and Task Technology

The general information processing (IP) model used in this study is based on contingency theory; that is, it adopts the view that effective performance is not assured by a given organizational design, but rather is

contingent upon an appropriate match of the contextual variables, such as task technology, and overall organizational arrangements including communication media in specified task environments (Rice, 1992).

Accordingly, the first two hypotheses presented in Sections 3.2.2.1 and 3.2.2.2—H. 1: the greater the degree of task variety, the greater the amount of perceived uncertainty; and H. 2: the greater the degree of task analyzability, the less the amount of perceived uncertainty—focus on variables associated with task technology with respect to the work environment in which employees regularly carry out their day-to-day activities. Task technology varies depending on individuals' responsibilities; these differences have been discussed in the literature (Finholt, Sproull, & Kiesler, 1990; Hiltz, Turoff, & Johnson, 1981; Mintzberg, 1983; Perrow, 1967; Randolph & Finch, 1977; Rice, 1992; Steinfield, 1986) and are explained below where relevant and applicable.

3.2.2.1 Variety and Uncertainty

Perrow (1967) was one of the first to suggest that two dimensions affect task technology. The first dimension, variety, was defined in Part 2 as the number of unanticipated events or cases that workers encounter; that is, variety refers to the degree to which task stimuli are familiar or unfamiliar. High levels of variety are equated with large numbers of exceptions (unusual circumstances) that occur during work. Large numbers of exceptions are theorized to increase the amount of uncertainty that employees experience, where uncertainty is defined as the difference between how much information is required to perform a task and the amount of information that the workers actually possess (Galbraith, 1973).

Variety and uncertainty are thus hypothesized to have a positive correlation: the more often that workers encounter exceptions in the daily routine (i.e., experience high levels of variety), the more often they are likely to experience high levels of uncertainty. People do seek to resolve uncertainty before proceeding with their work (Galbraith, 1974; Tushman & Nadler, 1978). Therefore, the notion that variety and uncertainty are positively correlated is tested by the first hypothesis:

Hypothesis 1: The greater the degree of task variety, the greater the amount of perceived uncertainty.

3.2.2.2 Analyzability and Uncertainty

A second dimension discussed by Perrow (1967) that influences task technology is analyzability. Somewhat related to variety, analyzability refers generally to the extent to which potential problems may be anticipated ahead of time, and the degree to which solutions may be planned in advance to cope with suspected problems.

High analyzability refers to a high capacity to provide procedural methods to solve difficulties. Low analyzability means that work methods and/or problems may not be readily amenable to careful scrutiny. This means that it is difficult to provide formal procedures to deal with problems when they do occur. As a result, high analyzability and uncertainty are hypothesized to be negatively correlated, and in highly analyzable environments perceived uncertainty will tend to be reduced (Daft & Lengel, 1986; Daft & Macintosh, 1981; Weick, 1979). This concept leads to the second hypothesis concerning the nature of task technology:

Hypothesis 2: The greater the degree of task analyzability, the less the amount of perceived uncertainty.

3.2.3 IP Requirements and Communication Media

3.2.3.1 Uncertainty and CMC

As suggested by the previous work of Simon (1962) and Galbraith (1974), organizations provide mechanisms of problem-solving to deal with uncertainty in the performance of task objectives. Uncertainty in this study has been defined as a lack of information which can be resolved through obtaining answers to specific questions. This research assesses uncertainty with respect to whether there is adequate information to make good decisions and whether job-related activities are well defined. To resolve problems of uncertainty, answers to straightforward questions do not normally require extensive discussion, and therefore, a rich medium (previously defined in Part 2 as a channel carrying a band of nonverbal context cues) is not needed to arrive at an answer. Rather, it is hypothesized that the most effective approach is to facilitate the exchange of specific, focused information through nonrich (sometimes called lean) media.

Nonrich or lean media provide individuals with the ability to exchange questions and answers rapidly. It is hypothesized, therefore, to be the most efficient mechanism to reduce uncertainty when it occurs. This rationale therefore leads to the third hypothesis:

Hypothesis 3: The greater the amount of uncertainty, the greater the use of CMC.

To the extent that higher levels of uncertainty will require increased levels of communication exchanges to resolve that uncertainty, we may expect the number of persons involved in the exchanges will correspondingly increase and by extension, include individuals who work outside of the organization's boundaries. To assess this phenomenon, the fourth hypothesis predicts a positive correlation between levels of uncertainty and use of CMC extending to remote persons:

Hypothesis 4: The higher the level of uncertainty, the more CMC use will extend to persons outside of the organization.

3.2.3.2 Analyzability and CMC

As an extension to the line of reasoning that predicts a positive correlation between uncertainty and CMC use (stated by H. 3), it is hypothesized further that CMC provides an efficient medium for handling the types of communication exchanges that are suitable for analyzable environments (Trevino, Lengel, & Bodensteiner, 1990). This view was researched by Rice (1992) who studied the correlation of analyzability of work environment and media use. The Rice study did indicate modest support for the contingent effect of task conditions affected by analyzability and use of new media. As an extension to previous research, therefore, the fifth hypothesis suggests:

Hypothesis 5: The greater the degree of analyzability, the greater the use of CMC.

3.2.3.3 Equivocality and CMC

Unlike the more or less clear-cut question and answer approach proposed by Daft and Macintosh (1981) to reduce uncertainty, some problems are instead associated with ambiguity or multiple interpretations about the environment which cause confusion and lack of understanding (Daft, Lengel, & Trevino, 1987). As explained above, for tasks that are subject to high degrees of analyzability, methods and practices can be developed in advance to deal with problems that arise. However, when problems occur involving unclear, messy fields that are highly ambiguous, such problems can cause confusion that is not easily reduced by obtaining answers to specific questions. Such situations are termed equivocal in nature. That is, equivocality is defined as the existence of several conflicting interpretations about the environment that may also include a corresponding lack of understanding about the best way to proceed. Not only are answers to specific questions missing, but even the questions themselves may not have been articulated (Daft & Lengel, 1986; Weick, 1979).

It is hypothesized that lessening the amount of equivocality requires ambiguity-reducing communications best served by information-rich media such as face-to-face conversations or group meetings. Information richness refers to media that have high levels of nonverbal context cues and are able to change understanding within a time interval; that is, communications that overcome frames of reference or clarify ambiguity in a timely manner are defined as rich (Daft & Lengel, 1986). As explained in the Part 2 literature review, several empirical studies have been presented on the extent to which CMC is or is not a rich communication medium (Fulk & Ryu, 1990; Rice,

1992; Schmitz & Fulk, 1990; Trevino, et al., 1990; Zmud, Lind, & Young, 1990). Because the literature asserts CMC does not facilitate highly information-rich exchanges, it is hypothesized here that CMC will not be used to reduce problems associated with equivocality:

Hypothesis 6: The greater the amount of perceived equivocality, the less the use of CMC.

3.3 IP Capabilities and Environmental Variables

3.3.1 Introduction

It has been proposed by the "School of Fit" theorists (Balaguer & Leifer, 1989; Daft & Lengel, 1986; Leifer, 1988; Trevino, et al., 1990; Triscari, 1984; Tushman & Nadler, 1978) that information processing requirements are determined by the workers' perceptions of uncertainty and equivocality as influenced by the variables of task technology and environmental influences. The IP capabilities are in turn affected by the available information technology. Effectiveness is thus viewed in this model as a function of the degree of fit between information processing requirements and information processing capabilities.

3.3.2 Communication Channels

The principal communication channels for reducing equivocality or uncertainty modeled after previous research (Daft & Lengel, 1984, 1986) consist of: rules and regulations, formal information systems, special reports, direct contact, integrators (assigned to a boundary-spanning activity within the organization), and group meetings. Although the above integrating

strategies are assessed separately in the survey itself, to establish the categories of measurement for the analysis and to make measurement of significant variables more compatible with other research, these media are combined where appropriate and reduced to five principal components:

1) written matter (printed, hard-copy documents)
2) CMC
3) telephone voice mail
4) telephone conversations
5) face-to-face communication

3.3.3 Effectiveness

Katz and Kahn (1966) stated that organizational effectiveness may be defined as the maximization of return to the organization by all means. Maximization of an organization's technical methodology (in this case, of communication processes) implies greater degrees of effectiveness. Without CMC, the members have to utilize other communication mechanisms which have certain disadvantages. For example, face-to-face conversation can result in considerable time lost by moving from one's workspace to ask a question, coupled with potential reluctance to make the effort to seek information when it is needed. Also, in active environments individuals may not be present at their workspaces because they are talking to someone else about another problem.

In another example, telephone communications can consume large amounts of time due to the disadvantages of busy lines, unproductive phone-tag, or unanswered messages. McCullough's (1984) research found that of

paper-based interoffice mail, 75–80% of it generated internally, is slow: it commonly took three days for mail delivery to the recipient, even in the case of single-page memos. With respect to these organizational communication problems, it is not surprising for Hammer and Mangurian (1987) to assert that the most immediate impact a communications-intensive information system can have on an organization is clear communication links, transmitted quickly among and between organizational units.

It is in part to overcome communication problems that the IP model contends that a useful strategy is to match information processing requirements with information processing capabilities to maximize effectiveness (Daft & Lengel, 1986; Leifer, 1988; Miles & Snow, 1986; Rice, 1992; Tyler, Bettenhausen, & Daft, 1989).

IP theory holds that different channels or modes of communication possess differential capabilities to reduce uncertainty and equivocality. It has been suggested by Trevino, et al. (1990) that CMC falls between the telephone conversation and a printed document with respect to measures of information richness and the capacity to reduce equivocality. Consequently, this research will re-examine the propositions of Daft and Lengel (1986) and Tushman and Nadler (1978) regarding the interrelationship of media characteristics and task accomplishment. Therefore, the following two hypotheses are proposed to test the relationships among communication channels, environmental influences, and communication effectiveness:

Hypothesis 7: Use of information-lean media will be more strongly associated with positive effectiveness measures in analyzable environments.

Hypothesis 8: Use of information-lean media will be less strongly associated with positive effectiveness measures in equivocal environments.

3.3.4 Matching IP Requirements with IP Capabilities

It was noted in Part 2 that variables associated with task technology and the environment, such as analyzability, affect the IP demands of employees. One of the claims of IP theory is that workers can increase effectiveness by matching the media they use to the characteristics of the task environment. Thus, if the tasks are highly analyzable, it is hypothesized that relying on information-rich media such as face-to-face conversations and group meetings is not an optimal solution. To assess this theoretical proposition, the following hypotheses are offered to examine the relationship between task environments and information processing capability:

Hypothesis 9: Effectiveness is positively related to media use when the medium is matched to task characteristics.

Hypothesis 10: Effectiveness is negatively related to media use when the medium is not matched to task characteristics.

3.4 Summary

This chapter presented ten hypotheses to be tested empirically, and illustrated certain theoretical relationships posited to exist among variables in the work environment. Attempting to integrate the two information

processing requirements of reducing uncertainty and equivocality, the proposed model of this research examined how contextual variables of task technology and environmental influences can affect information needs and explored whether effectiveness may be best achieved by optimizing the degree of fit as proposed by IP theory. Table 3–1, on the following page, summarizes these ten hypotheses. The next chapter, Part 4, details how the specific hypotheses are tested in this research. Results are given in Part 5, and a discussion of the findings is presented in Part 6.

Table 3–1

SUMMARY LIST OF HYPOTHESES

H. 1:	The greater the degree of task variety, the greater the amount of perceived uncertainty.
H. 2:	The greater the degree of task analyzability, the less the amount of perceived uncertainty.
H. 3:	The greater the amount of uncertainty, the greater the use of CMC.
H. 4:	The higher the level of uncertainty, the more CMC use will extend to persons outside of the organization.
H. 5:	The greater the degree of analyzability, the greater the use of CMC.
H. 6:	The greater the amount of perceived equivocality, the less the use of CMC.
H. 7:	Use of information-lean media will be more strongly associated with positive effectiveness measures in analyzable environments.
H. 8:	Use of information-lean media will be less strongly associated with positive effectiveness measures in equivocal environments.
H. 9:	Effectiveness is positively related to media use when the medium is matched to task characteristics.
H. 10:	Effectiveness is negatively related to media use when the medium is not matched to task characteristics.

REFERENCES CITED IN PART 3

Balaguer, N. S. (1988). CIM information technology utilization and organizational design: A field study on information processing. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Balaguer, N. S., & Leifer, R. P. (1989). Information processing capabilities and organizational design: A model and field study. (Working paper), Harvard Business School, Cambridge, MA, and Rensselaer Polytechnic Institute School of Management, Troy, NY.

Bourgeois, L. J. (1985). Strategic goals, perceived uncertainty, and economic performance in volatile environments. Academy of Management Journal, 28, 548–573.

Daft, R. L., & Lengel, R. H. (1984). Information richness: A new approach to managerial behavior and organization design. In B. M. Straw & L. L. Cummings (Eds.), Research in organizational behavior (pp. 191–233). Greenwich, CT: JAI Press.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. Management Science, 32, 554–571.

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection, and manager performance: Implications for information systems. Management Information Systems Quarterly, 11, 355–366.

Daft, R. L., & Macintosh, N. B. (1981). A tentative exploration into the amount and equivocality of information processing in organizational work units. Administrative Science Quarterly, 26, 207–224.

Dill, W. R. (1958). Environment as an influence on managerial autonomy. Administrative Science Quarterly, 2, 409–443.

Downey, H. K., Hellriegel, D., & Slocum, J. R. (1975). Environmental uncertainty: The construct and the application. Administrative Science Quarterly, 20, 613–629.

Duncan, R. B. (1972). Characteristics of organizational environments and perceived uncertainty. Administrative Science Quarterly, 17, 313–327.

Duncan, R. B. (1973). Multiple decision-making structures in adapting to environmental uncertainty: The impact on organizational effectiveness. Human Relations, 26(3), 273–291.

Finholt, T., Sproull, L., & Kiesler, S. (1990). Communication and performance in ad hoc task groups. In J. Galegher, R. Kraut, & C. Egido (Eds.), Intellectual teamwork: Social and technological foundations of cooperative work (pp. 291–325). Hillsdale, NJ: Lawrence Erlbaum.

Ford, J. D., & Slocum, J. W. (1977). Size, technology, environment and the structure of organizations. Academy of Management Review, 2, 561–575.

Fulk, J., & Ryu, D. (1990). Perceiving electronic mail systems: A partial test of social information processing model of communication media in organizations. ICA, Dublin.

Galbraith, J. R. (1973). Designing complex organizations. Reading, MA: Addison-Wesley.

Galbraith, J. R. (1974). Organization design: An information processing view. Interfaces, 4, 28–36.

Hammer, M., & Mangurian, G. E. (1987). The changing value of communications technology. Sloan Management Review, 28, 65–71.

Hernon, P., & Pinelli, T. E. (1992). Scientific and technical policy and the competitive position of the U.S. aerospace industry. (AIAA–92–0796). Washington, DC: AIAA.

Hiltz, S. R., Turoff, M., & Johnson, K. (1981). Effect of structure, task, and individual attributes on consensus in computerized conferences. In The IFIP TC–6 International Symposium on Computer Message Systems, (pp. 91–102). Ottawa, Canada: North-Holland Publication Co.

Katz, D., & Kahn, R. L. (1966). The social psychology of organizations. New York: Wiley.

Kraemer, K. L., & Pinsonneault, A. (1990). Technology and groups: Assessment of the empirical research. In J. Galegher, R. Kraut, & C. Egido (Eds.), Intellectual teamwork: Social and technological foundations of cooperative work (pp. 375–405). Hillsdale, NJ: Lawrence Erlbaum.

Lawrence, P. R., & Lorsch, J. W. (1967). Organization and environment. Homewood, IL: Richard Irwin.

Leifer, R. (1988). Matching computer-based information systems with organizational structures. Management Information Systems Quarterly, 12, 63–73.

Leifer, R., & Huber, G. P. (1977). Relations among perceived environmental uncertainty, organizational structure, and boundary-spanning behavior. Administrative Science Quarterly, 22, 235–247.

Leifer, R., & Triscari, T. (1987). Organizational information processing characteristics and computer-based information systems design. (Working paper), School of Management, Rensselaer Polytechnic Institute, Troy, NY.

McCullough, P. (1984). Fundamentals of IBM computer systems. Chicago: Science Research Associates.

Miles, R. E., & Snow, C. C. (1986). Organizations: New concepts for new forms. California Management Review, 28, 62–73.

Mintzberg, H. (1983). Structure in fives: Designing effective organizations. Englewood Cliffs, NJ: Prentice-Hall.

Perrow, C. (1967). A framework for the comparative analysis of organizations. American Sociological Review, 32, 194–208.

Pinelli, T. E. (1991). The relationship between the use of U.S. Government technical reports by U.S. aerospace engineers and scientists and selected institutional and sociometric variables. (NASA Technical Memorandum 102774-6). NASA.

Randolph, W., & Finch, F. (1977). The relationship between organizational technology and the direction and frequency dimensions of task communications. Human Relations, 30, 1131–1145.

Rice, R. E. (1992). Task analyzability, use of new media, and effectiveness: A multi-site exploration of media richness. Organization Science, 3(4), 475–500.

Schmitz, J., & Fulk, J. (1990). The role of organizational colleagues in media selection. ICA, Dublin.

Simon, H. A. (1962). The architecture of complexity. Proceedings of the American Philosophical Society, 106, 467–482.

Steinfield, C. W. (1986). Computer-mediated communication in an organizational setting: Explaining task-related and socioemotional uses. In M. L. McLaughlin (Eds.), Communication yearbook 10 (pp. 777–804). Beverly Hills, CA: Sage.

Trevino, L. K., Daft, R. L., & Lengel, R. H. (1990). Understanding managers' media choices: A symbolic interactionist perspective. In J. Fulk & C. Steinfield (Eds.), Organizations and communication technology (pp. 71–94). Newbury Park, CA: Sage.

Trevino, L. K., Lengel, R., & Bodensteiner, W. (1990). The richness imperative and cognitive style: The role of individual differences in media choice behavior. Management Communication Quarterly, 4(2), 176–197.

Triscari, T. (1984). Organizations and information processing: A field study of research and development units within the United States Air Force systems command. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Tushman, M. L., & Nadler, D. A. (1978). Information processing as an integrating concept in organizational design. Academy of Management Review, 3, 613–624.

Tyler, B. B., Bettenhausen, K. L., & Daft, R. L. (1989). The use of low and high rich information sources and communication channels in developing and implementing competitive business strategy. Academy of Management Proceedings, pp. 245–249.

Weick, K. E. (1979). The social psychology of organizing (2nd ed.). Reading, MA: Addison Wesley.

Zmud, R., Lind, M., & Young, F. (1990). An attribute space for organizational communication channels. Information Systems Research, 1(4), 440–457.

PART 4

METHODS

4.1 Introduction

Expenditures for this research to investigate media use among aerospace personnel were funded under grants from the Society for Technical Communication (STC) and Phase 1 of the NASA/DoD Knowledge Diffusion Research Project. The Knowledge Diffusion Project began out of concern for the future of the U.S. aerospace industry. From the beginning, the Project acknowledged that NASA did not understand scientific and technical information (STI) transfer as much as it needed to. Specifically, NASA did not know how information users (industry engineers, intermediaries, providers) shared STI. Among the missing pieces were data on characteristics of aerospace work environments, and data on how personnel used information-sharing resources, including media preferences (Kennedy, 1993).

This research measures twelve variables associated with the technical communication practices of aerospace engineers and scientists. Data were collected from a random sample of aerospace workers throughout the U.S. who belong to the American Institute of Aeronautics and Astronautics (AIAA). The research examined specified variables in the aerospace environment and the communication mechanisms used by the employees. The study obtained data about the use of electronic networks in information gathering as well as the patterns of group communications and other STI diffusion behaviors. Under the advice and direction of the dissertation committee, the author selected the theoretical model, specified the relevant variables to be measured, and performed the overall research analysis. The

Knowledge Diffusion Research Project personnel provided suggestions at various times, but did not direct the research.

4.2 The Survey Instrument

According to Denzin (1970a), the survey, the interview, and multivariate analysis are among the favored methods of sociological inquiry. This project also employed these methodologies, and they are explained in greater detail in the subsections of Part 4 that follow. For the survey part of the study, the Total Design Method as explained by Dillman (1978) constituted the overall strategy and procedures.

The quantitative data collection instrument used a series of questions (most of which were posed in five-point, Likert-scales) to investigate the variables targeted in the research. The five-point scale was used for three reasons: 1) to match the scales of those used in a previous IP study (Balaguer, 1988); 2) to match the instrument's format to other studies' layouts in the Knowledge Diffusion Research Project; and, 3) to minimize a leveling off in reliability measures for scales with more than five points as reported by Lissitz and Green (1975).

According to the design principles of Dillman (1978), the survey document was printed as a twelve-page booklet and also had a computer-generated logo on its cover. The title on it was "Computer-Mediated Communication (CMC) and the Communication of Technical Information in Aerospace." The survey had 116 items (not including 13 items to obtain demographic data), and it was divided into eight sections to target specific variables and dimensions.

4.3 Collection of Quantitative Data

To obtain the subjects, the Knowledge Diffusion Research Project personnel at NASA Langley Research Center obtained a database of 6,000 names and addresses of members of the AIAA and sent it to the author in January, 1992. The procedure utilized a table of random numbers to obtain the starting point and the interval number for a computer program to generate a systematic random sample of 2,000 subjects from the original database.

After pilot testing the instrument on two separate occasions ($N = 19$) and making minor modifications to the question wording, the surveys were printed and mailed to the randomly chosen subjects on Monday, May 3, 1993. (A copy of the survey instrument is included in Appendix B.) The packet included the survey, two cover letters (copies in Appendix C), and a postage-paid return envelope. Although each survey had a code printed on its back cover to track response rates, no identification of the subjects' identities was made. The Indiana University Center for Survey Research in Bloomington, Indiana, handled both the mailing of the questionnaires and the data entry, which was performed in an on-going basis as the surveys were returned. To ensure confidentiality of the subjects, the Center retained all identification data concerning respondents, and this information has not been provided to the author.

After the initial mailing, a follow-up postcard was sent to all of the subjects (sample in Appendix D) on May 13, 1993. By mid-June, nearly 600 surveys had been returned. On Monday, June 21, a second mailing of survey

packets under a different cover letter (copy in Appendix B) was sent to the respondents who had not yet sent in their replies. The Center continued to receive replies over most of the summer, so data entry cut-off did not occur until September 7, 1993. By then, quantitative data from 1,006 usable surveys had been input and checked for errors by the staff at the Center (copy of Center's data report in Appendix E). Other error-checking procedures undertaken by the author are explained in subsequent sections that describe the hypothesis-testing methods in detail. Quantitative data analysis was carried out using the Statistical Package for the Social Sciences (SPSS) software for Macintosh, version 4.0, on an Apple Quadra 700 computer.

A summary of the sources for the survey instrument variables is provided in Table 4–1, and a summary of the research variables with corresponding item numbers is listed in Table 4–2. To identify the ways in which the instrument was used to analyze the data and test empirically the ten hypotheses presented in Part 3, a description and discussion of the survey's items is offered in the next section.

4.4 Variables of Task Technology

As discussed previously in Part 2, the contextual variables of organizations influence their information processing requirements. Here, the contextual dimension to be assessed is task technology, that is, the degree to which the work is marked by variety and analyzability.

Table 4–1

SOURCES FOR SURVEY INSTRUMENT VARIABLES

Variable	Dimensions	# Items	Sources
Task Technology	Variety	4	From Withey, Daft & Cooper (1983)
	Analyzability	4	
Operationalized Media	Face-to-Face;	12	Based on Galbraith (1973); Daft & Lengel (1986); Balaguer (1988); Triscari (1984); Pinelli (1993)
	Written;	8	
	Electronic	27	
IP Requirements	Uncertainty	5	Based on Downey, Hellriegel, & Slocum (1975); Balaguer (1988)
	Equivocality	6	From Daft & Macintosh (1981); Balaguer (1988)
IP Capabilities	Importance; Frequency; Accuracy; Usefulness; Specificity; Sufficiency; Ease; Load	32	Based on O'Reilly (1982); Triscari (1984); Balaguer (1988)
Effectiveness	Overall	8	From Triscari (1984); Balaguer (1988)

Table 4–2

SURVEY VARIABLES WITH CORRESPONDING ITEM NUMBERS

Variable	Item Number (R = Reverse scored)
Task Technology	
Variety	1a-R, 1c, 1e-R, 1h
Analyzability	1b, 1d-R, 1f-R, 1g
Operationalized Media	
Written	12a, 12b, 13a, 13b, 14a, 14b, 15a, 15b
CMC	12c, 13c, 14c, 15c, 16, 17, 18, 19 20a, 20b, 20c, 20d, 20e, 20f 20g, 20h, 20i, 20j, 20k
Voice Mail	12d, 13d, 14d, 15d
Telephone	12e, 13e, 14e, 15e
Face-to-Face (1 on 1)	12f, 13f, 14f, 15f
Liaisons	12g, 13g, 14g, 15g
Group Meetings	12h, 13h, 14h, 15h
Influences on IP Requirements	
Uncertainty	1l-R, 1m-R, 1n-R, 3d-R, 3e-R
Equivocality	1i, 1j, 1k, 3a, 3b, 3c
Overall Effectiveness	22a, 22b, 22c, 22d 22e, 22f, 22g, 22h

4.4.1 Task Variety

High variety implies that the tasks change considerably from day to day or even from hour to hour. Low variety implies little variation in the tasks to be performed. Variety was assessed by four separate items in the survey (R=reverse scored):

1. The work is routine. (1a–R)
2. The tasks performed differ greatly from day-to-day. (1c)
3. We use repetitive activities in doing the work. (1e–R)
4. Our tasks require the use of many skills. (1h)

Each of these items was measured with a five-point Likert scale ranging from 1–Strongly Disagree to 5–Strongly Agree. Although the items are listed together here, they were actually interspersed among other items in the questionnaire that targeted different variables.

The composite scale range of overall variety was computed as the unweighted sum of the scores for all items so that the possible extreme scores range from 4 ("1" scored for each item) to indicate the lowest level of variety, to 20 ("5" scored for each item) to indicate the highest level of variety.

To divide respondents into low or high variety groups for analysis, the lower and upper quartile range division on overall variety were used. The quartile range split is more desirable than the more common median split because it provides more robust separation of the variable under analysis, and it helps to control for middle-range scores that are not of interest (Norušis, 1990).

4.4.2 Task Analyzability

As described in Part 3, analyzability refers to how well problems may be planned for. Low analyzability implies that the tasks are not easily defined and/or understood. It suggests that the tasks are too complex for standardized approaches to problem-solving and/or resist structured schemes to cope with them. On the other hand, highly analyzable tasks can be carefully scrutinized and planned for in advance (Mintzberg, 1983).

The survey instrument used four items to measure analyzability (R=reverse scored):

1. There is an ordered sequence to be followed in carrying out the work. (1b)
2. It is difficult to specify a sequence for carrying out the work. (1d–R)
3. Established procedures exist for most work. (1f–R)
4. We rely on established procedures and practices to do the work. (1g)

The unweighted sum of each five-point Likert scale was computed to provide an overall measure of analyzability. As with the items to assess variety listed above, the analyzability items are listed together here, but were interspersed among other items on the actual questionnaire.

4.5 Coordination Mechanisms and Media Components

The principal coordination mechanisms for reducing equivocality or uncertainty as adapted from the Daft and Lengel (1986) integration strategies consist of the following: rules and regulations; formal information systems;

special reports; planning; direct contact; integrators (assigned to a boundary-spanning activity within the organization); and group meetings. As given in Part 2, these mechanisms are operationalized as seven principal media components for data analysis (Ferguson, 1981). The media are as follows:

1) written matter, that is, printed copies of formal reports and other documents (e.g., letters, memos, notes);
2) CMC;
3) telephone voice mail;
4) telephone conversations;
5) face-to-face (1 on 1) communication;
6) liaisons;
7) group meetings.

As explained in Part 2, the more information-rich mechanisms (face-to-face and telephone use) are hypothesized to be better-suited for reducing equivocality, and the less information-rich mechanisms (written documents and CMC) are hypothesized to be better-suited for reducing uncertainty. The survey respondents indicated on the survey instrument how many times in a typical work week the mechanisms were used to obtain or provide information both within and without their respective departments and organizations. Individual scale items were subjected to factor analysis, and items that loaded less than .50 on the factor were dropped for the final procedures. This helped in the analysis of the data by preventing marginal influences from entering the equation; that is, only factor items that contributed .50 or more were kept in the computation (Rummel, 1970).

4.6 Uncertainty

Drawing upon previous work by Balaguer (1988) and Downey, Hellriegel, and Slocum (1975), measures of uncertainty in this research are associated with contextual variables of task technology and the communication media used by the workers. The individual items to evaluate these relationships are defined with respect to three foci:

1) the extent to which there is adequate information to make good decisions;
2) the extent to which decisions affect overall performance;
3) the extent to which job-related activities are clearly defined in the coordination of work.

Specifically, five items assessed degrees of uncertainty, and the items are as follows (R=reverse scored):

1. The information we have is adequate for making good work decisions about my department's tasks or problems. (1l–R)
2. I can tell if my decisions affect my department's performance. (1m–R)
3. My job requirements are clear to me. (1n–R)
4. I can identify the effect decisions about work coordination have on my department's performance. (3d–R)
5. My job requirements are clear for coordinating work with other departments. (3e–R)

The items were subjected to reliability tests and factor analysis to examine the measurement scale. Then, degrees of overall uncertainty were

obtained by calculating the unweighted sum of the item scales across all subjects.

4.7 Equivocality

Equivocality was defined as the absence of understanding caused by ambiguity or the existence of multiple and conflicting interpretations (Daft & Lengel, 1986; Daft & Macintosh, 1981; Weick, 1979). In practice, equivocality may arise in situations where shared points of view go unrecognized or where there is simply not a precise answer to a question. Thus, raising questions due to confusion and ambiguity, followed by negotiating answers to these questions among members, represents the domain of equivocality (Daft & Weick, 1984; Weick, 1979). Overall, situations involving equivocality are less focused than those involving uncertainty. The items to evaluate equivocal relationships are defined with respect to three dimensions based upon previous work of Balaguer (1988) and Daft and Macintosh (1981):

1) the ways in which information can be interpreted;
2) the extent to which problems have more than one acceptable solution; and,
3) the extent to which information to make decisions can mean different things to different people.

Specifically, there are six items to assess degrees of equivocality:

1. Work information can be interpreted in several ways. (1i)
2. We face problems which have more than one acceptable solution. (1j)

3. Information about work activities can mean different things to different members of my department. (1k)
4. Information about coordinating work can be interpreted in several ways. (3a)
5. More than one satisfactory solution exists for ways to coordinate work activities with other departments. (3b)
6. Co-workers interpret interdepartmental coordination policies differently. (3c)

After examining the individual items with reliability tests and factor analyses to ascertain the robustness of the scale, overall degrees of equivocality were obtained by calculating the unweighted sum of the item scales across all respondents.

4.8 Information Processing Requirements

For exploratory analysis, work-related communication requirements have been operationalized according to the following two dimensions:

1) importance of the communication channel;
2) adequacy of information.

The research survey employs six items (three for each dimension) to measure IP requirements as previously specified in Table 4–2. An overall measure of information processing requirements was assessed by summing the items over all of the unit members.

4.9 Information Processing Capabilities

Items used to measure information processing capability for exploratory analysis in Part 6 are based upon previous research by O'Reilly (1982), Triscari (1984), and Balaguer (1988). The work-related communication capabilities are operationalized according to the following dimensions:

1) importance of the information;
2) frequency of using the information source;
3) accuracy of the information;
4) usefulness of an information source;
5) specificity of the information;
6) sufficiency of the information;
7) degree of ease to obtain the information;
8) amount (load) of the information.

Measures of IP capabilities are assessed as the unweighted sum of the individual scale items. Possible alternative approaches to analyze media are suggested in Part 6, Discussion and Conclusion.

4.10 Effectiveness Evaluation

An important measure of the research—effectiveness—endeavored to measure whether some individuals are more effective in their work performance than others. To assess individual effectiveness, this study adapted a questionnaire developed by Triscari (1984) and Balaguer (1988) that contains eight statements about performing work. Like the other survey questions, this evaluation of work performance was completed by the individual respondents. As a method of inquiry, using self-report measures

on performance effectiveness is consistent with general strategies for collecting data using an anonymous survey (Babbie, 1979).

Babbie (1979) stated that all surveys collect self-reports of recalled past action or hypothetical action, so when it comes to dealing with a sensitive issue—such as assessing one's own performance—the anonymous self-report is an appropriate technique. He said that some respondents might be reluctant to report "controversial" attitudes or behaviors in, say, an interview, but they might be willing to do so more readily on a self-report survey. As mentioned above, using this procedure also controls for problems associated with interview or observer bias while encouraging more candid responses on what could be interpreted as a sensitive issue.

After examining the instrument's effectiveness scale with reliability and factor analysis tests, an overall measure of effectiveness was computed as the unweighted sum of the items over all respondents.

4.11 Analysis of Quantitative Data

As discussed previously in Section 4.3, the field collection of the data concerning contextual design variables, information processing activities, and organizational design variables was obtained on-site from workers by means of the survey instrument. Results of the study are reported only in summarized, aggregate form. No identifications are made of individuals.

Five-point Likert scales were used to measure most of the quantitative items. Listed below are sample scales, separated by scoring direction:

5 points were given for Agree Strongly;

4 points were given for Agree;

3 points were given for Neutral;

2 points were given for Disagree;

1 point was given for Disagree Strongly.

For reverse scoring situations, the following scale was used:

1 point was given for Agree Strongly;

2 points were given for Agree;

3 points were given for Neutral;

4 points were given for Disagree;

5 points were given for Disagree Strongly.

4.12 Hypothesis Testing

The methodologies to examine the hypotheses of the research utilized various statistical procedures that included tests of reliability, *t*-tests, correlations, regression, analysis of covariance (ANCOVA), and factor analysis. Cronbach's (1951) alpha coefficient and the Kaiser-Meyer-Olkin (1974) measure for sampling adequacy were taken to assess scale reliability. Tests for curvilinearities (e.g., Eta and residual plots) and tests for multicollinearity (e.g., Variance Inflation Factors and Variance Decomposition Proportions) were applied to the variables, and alternative tests were used when warranted. For example, if a residual plot indicated that a sample was not normally distributed, then a nonparametric, distribution-free test such as the Mann-Whitney *U* test was used in place of the parametric *t*-test which is more sensitive to departures from normality. The two following paragraphs explain this strategy in more detail.

A common issue that confronts social science research in general centers around the criteria one uses to choose among a variety of statistical procedures. Blalock (1979) holds that in most practical instances, the researcher will not know enough about the true parameter values to make definitive decisions. And, although parametric procedures seem to be reasonably robust under many conditions, there remains some concern as to the advisability of using such tests if there seem to be distortions of various kinds in the data, especially if reasonably satisfactory nonparametric methods are available to the researcher. Blalock's (1979) position is that one cannot give simple, dogmatic answers to questions of which kind of test or measure is most appropriate. Thus, when conditions arise that require a decision between relative power efficiencies of some tests versus the situation where some tests have stronger assumptions than others, the researcher is best advised to use different tests, both parametric and nonparametric, and then report both sets of results so that the readers can make their own decisions.

Blalock (1979) states that the preferred method for doing so is to report the result of the second test in footnotes that might include any additional comments to suggest why results may not have been identical. This dissertation takes a cautious approach to the data and follows his recommendation, using the nonparametric Mann-Whitney *U* test as the alternative statistical measure to the parametric *t*-test in any situation where regression analysis of the studentized residuals indicated a data distribution having anything more than a minor departure from normality. The reason the Mann-Whitney *U* test is used in place of the two-group *t*-test is because the *U* test is less sensitive to departures from normal sampling distribution

(Siegel, 1956; Young & Veldman, 1981). Use of the nonparametric procedure was done in conjunction with hypothesis tests that commonly rely on normally distributed samples if the samples violated the tests' assumptions. In such cases, scatterplots of the residuals are included in the dissertation along with the results of both the *t*-test and the *U* test, so that the readers may both assess the researcher's interpretation of the tests and also judge the outcomes for themselves.

The hypotheses tests reported in this section are based on the 99% confidence level that the correlation coefficients are not equal to zero. Tables 5–2 and 5–3 in Part 5, Results, list the number of valid responses, the means, the standard deviations, and the alpha coefficients of the variables explicitly named in the operationalized hypotheses. Principal-component (PC) factor analysis using varimax (orthogonal) rotation examined the contribution of the individual dimensions (e.g., variety and analyzability with respect to task technology) for each of the variables.

The following ten sections describe the procedures taken to test the hypotheses. It should be pointed out that some scales and procedures are used for more than one hypothesis test. To avoid repetition, such steps are referenced, but not explained again in detail.

4.12.1 Hypothesis 1

H. 1: The greater the degree of task variety, the greater the amount of perceived uncertainty.

To study the impact of environmental factors, the first hypothesis tests the relation proposed to exist between task variety and perceived uncertainty.

The first step computed item correlation matrices for both variable sets of variety and uncertainty. The correlation coefficients were calculated to assess the extent to which the individual scale items correlated with one another. Next, a reliability analysis, scale alpha, using the covariance matrix was applied. Before the principal-components (PC) factor analysis was used to examine how the individual items loaded on common factors, the Kaiser-Meyer-Olkin (KMO) measure for sampling adequacy was run to see if the variety and perceived uncertainty datasets were amenable to factor analysis. Also, because certain statistical procedures such as the *t*-test used later in this analysis assume a normal distribution, normal probability (P–P) plots were computed to examine the data for departures from normality. In this procedure, the observed cumulative proportion at various points were plotted against the expected cumulative proportion based on a normal distribution of standardized values. If the data were a sample from a normal population, the points should fall somewhat close to a straight line (Noruŝis, 1990).

After examining the distribution, overall reliability, and common factors of the scales, high and low quartile ranges for variety were calculated to divide subjects into high and low task variety groups. To test H. 1 empirically, a *t*-test of independent means was applied to test the null hypothesis that there would be no difference in the amounts of perceived uncertainty between the high and low task variety groups.

The *t*-test was used here as the hypothesis test because in the literature, the assumptions regarding the contextual variables (variety, uncertainty, analyzability, etc.) are generally given in terms of "low" and "high" measures

(Balaguer, 1988; Daft & Lengel, 1986; Leifer & Triscari, 1987; McDonough III & Leifer, 1983; Rice, 1992; Triscari, 1984; Tushman & Nadler, 1978). That is, these dimensions are commonly illustrated in a two-by-two matrix (i.e., low versus high demarcations on the axes) as they were presented in Part 2, so the variable of interest lies with differences between groups stratified by low and high levels of variety.

4.12.2 Hypothesis 2

H. 2 The greater the degree of task analyzability, the less the amount of perceived uncertainty.

As the next step in examining environmental factors, the second hypothesis tests the relation proposed to exist between task analyzability and uncertainty. An item correlation matrix was computed for the analyzability variable to assess the extent to which the individual scale items correlated with one another. Scale alpha analysis was applied to examine reliability. Before the principal-components (PC) factor analysis was used, a KMO procedure for sampling adequacy was run to see if the analyzability data were amenable to factor analysis. A normal probability plot and a residuals' scatterplot were computed to examine the data for departures from normality.

After examining distribution, reliability, and common factors of the scales, high and low quartile ranges were calculated to divide subjects into environments of high and low analyzability. Analysis of the residuals (provided in the next chapter) indicated that the data adhered closely to a normal distribution. A *t*-test was applied to H. 2 to test the null hypothesis that there would be no difference in the levels of perceived uncertainty

between the respondents who worked in highly analyzable aerospace environments and the respondents who worked in environments that were characterized by low analyzability.

4.12.3 Hypothesis 3

H. 3: The greater the amount of uncertainty, the greater the use of CMC.

Continuing the analysis of environmental factors, the third hypothesis tests the relation proposed to exist between perceived uncertainty and use of CMC media. The same uncertainty scale used to test H. 1 and H. 2 was also used here for H. 3. The low and high quartile ranges for uncertainty were computed to divide the sample into low and high uncertainty groups. For the CMC variable, numeric data for this analysis were obtained from survey question 19 which asked respondents to indicate how many hours "in a typical past week" they used CMC. A normal probability plot and a histogram of studentized residuals were computed to examine the data for departures from normality. These plots are illustrated in Figures 5–5 and 5–6 in the next chapter.

The plots of the residuals indicated departure from normality. To test H. 3, therefore, both the nonparametric Mann-Whitney *U* test (to compensate for the CMC scale's departure from a normalized distribution) and the parametric *t*-test, were applied to the data. Both measures tested the null hypothesis that there would be no difference between the amounts of reported CMC use between the low and high uncertainty groups.

4.12.4 Hypothesis 4

H. 4: The higher the level of uncertainty, the more CMC use will extend to persons outside of the organization.

The fourth hypothesis tests the relation proposed to exist between perceived uncertainty and CMC use that extends to individuals outside of the organization. The same high and low quartile ranges for uncertainty used previously were applied here. However, for the CMC variable, a different survey item was used that specifically addressed CMC use to individuals who were outside of the boundaries of the organization. For this measure, numeric data were obtained from survey question 21d which asked respondents to indicate how many times "in a typical week" they used CMC to communicate with people outside of the organization.

As was done with H.3, to test H. 4, both the *t*-test and the nonparametric Mann-Whitney *U* test were used to compensate for the CMC scale's departure from a normalized distribution. Both procedures tested the null hypothesis that there would be no difference between the high and low uncertainty groups regarding the amounts of reported CMC use extending to persons outside of the organization.

4.12.5 Hypothesis 5

H. 5: The greater the degree of analyzability, the greater the use of CMC.

The fifth hypothesis is an extension of previous tests involving factors in the work environment and media use. It tests the relation proposed to exist between degrees of analyzability and use of CMC media. The same

analyzability scale used to test H. 2 was also used for this test of H. 5. As before, the high and low quartile ranges for analyzability were computed to divide the sample into high and low environmental analyzability groups.

For the CMC variable, numeric data for this analysis were the same as those used in the analysis of H. 3 where the respondents indicated the approximate number of hours that they used CMC in a typical past week while working on their jobs. For H.5, the *t*-test and the nonparametric Mann-Whitney *U* test were applied to compensate for the CMC scale's departure from a normalized distribution to test the null hypothesis that there would be no difference in amounts of reported CMC use between the high and low analyzability groups.

4.12.6 Hypothesis 6

H. 6: The greater the amount of perceived equivocality, the less the use of CMC.

The sixth hypothesis tests the relation proposed to exist between degrees of equivocality in the environment and use of CMC media. The equivocality scale was examined using the same steps explained above for the other scales. That is, first the item correlation matrix for the equivocality variable set was calculated to assess the extent to which the individual scale items correlated with one another. Next, the scale alpha reliability analysis was applied.

The KMO measure for sampling adequacy was run to see if the dataset was amenable to factor analysis before the principal-components (PC) factor analysis was used to examine how the individual items loaded on common

factors. A normal probability plot was computed to assess the normality of the sampling distribution. Lastly, the high and low quartile ranges for equivocality were computed and used to divide the respondents into high and low equivocality groups.

For the CMC variable, numeric data used for this analysis were the same as those in the previous analyses of H. 3 and H. 5 involving the number of hours that the subjects reported using CMC in a typical work week. To perform the analysis of H. 6, the *t*-test and the nonparametric Mann-Whitney *U* test were again applied to compensate for the CMC scale's departure from a normalized distribution to test the null hypothesis that there would be no difference in the amounts of reported CMC use between the high and low equivocality groups.

4.12.7 Hypothesis 7

H. 7: Use of information-lean media will be more strongly associated with positive effectiveness measures in analyzable environments.

This hypothesis examines the relation proposed to exist among analyzability, media use, and overall effectiveness. In some aspects, the analysis was modeled after Rice's (1992) study of similar variables; that is, the basic strategy involved correlating usage and performance components within groups stratified by low and high degrees of analyzability. Results can be tested to identify the direction and significance of each of the two correlations and the extent of the difference. The difference between the two correlations of media use and overall effectiveness can be assessed by applying

a test of significance on the difference of the Z′ transformations of the correlations (Kleinbaum and Kupper, 1978).

The media scale was developed by combining selected items from the survey. First, the items on media use from questions 12–15 were tested with the KMO measure for sampling adequacy. Then, the principal-components (PC) factor analysis was used to identify discrete factors and assess their saturation with respect to media richness. The factor items were examined with scale alpha to assess reliability. The results of the factor analysis and the factor loadings are provided and explained in more detail in Part 5, but essentially, the PC factor analysis extracted two principal components for lean media: 1) written documents, and 2) CMC.

A series of COMPUTE statements recoded the scale items to divide reported media use into quartile ranges to create a more stable interval scale that controls for severe outliers in the data and also prevents undue weighting of one variable over another. For example, one might expect subjects received more telephone calls in a week than they attended group meetings. Merely summing the items would therefore cause telephone media to exert undue influence in the analysis. Recoding use of the media on a percentage-of-use basis helps prevent the more frequent use of the telephone media from exerting undue influence over the group meeting variable.

The effectiveness scale consisted of the unweighted sum of the eight five-point, Likert scale items in the survey: question 22, items a–h. Before used for hypothesis testing, the eight items were examined with both PC factor analysis and scale alpha to assess the reliability.

The method to carry out the hypothesis-testing procedure consisted of an analysis-of-covariance (ANCOVA) technique in a three-variable case involving one nominal variable and two interval scales as described by Blalock (1979). The dependent (criterion) variable was effectiveness. The independent variable was media use. As mentioned above, these two interval scales consisted of summational scores for items measuring frequency of media use and items measuring overall effectiveness.

The nominal scale, low vs. high analyzability, was obtained by using the H. 1 analyzability scale's lower and upper quartile ranges. In other words, the nominal analyzability variable represents the interval analyzability scale that has been categorized. The basic problem was one of relating the two interval scales of effectiveness and media use while controlling for the nominal scale of task environment, that is, low or high analyzability. The ANCOVA procedure relates the differences between effectiveness and media use within categories of the control (analyzability) variable.

After selecting subjects from the appropriate analyzability quartile range (low or high), the coefficient is obtained in a multiple regression procedure that enters the media scale on step number one with effectiveness declared as the dependent variable (Blalock, 1979). The calculation of the transformation of r to Z' to normalize sampling distributions of correlations is given by Kleinbaum and Kupper (1978):

$$Z' = \frac{\frac{1}{2}\log_e\left(\frac{1+r_1}{1-r_1}\right) - \frac{1}{2}\log_e\left(\frac{1+r_2}{1-r_2}\right)}{\sqrt{\frac{1}{N_1-3}+\frac{1}{N_2-3}}} \qquad (4.1)$$

It is possible to test the significance of the difference between the two sample values by using the equation to convert the correlations (r_1 and r_2) to their respective Z' values. Next, the difference between the two is divided by the square root of the inverse of the sum of $(N - 3)$ for each group. The absolute value of the result is evaluated by a table of Z' values, and for a two-tailed test must exceed the critical value of 2.58 at $p \leq .01$ to reject the null hypothesis that the coefficients for the low and high analyzability groups are the same.

4.12.8 Hypothesis 8

H. 8: Use of information-lean media will be less strongly associated with positive effectiveness measures in equivocal environments.

This hypothesis also examines the relation among media use, overall effectiveness, and environmental influence; the method is essentially similar to the one used in H. 7. For this analysis, the main difference lies in the stratification of groups: using equivocality instead of analyzability for the nominal variables. Also, this hypothesis predicts a weak rather than a strong association of lean media with effectiveness due to the environmental influence of equivocality. Otherwise, the basic strategy involved in correlating usage and performance components within stratified groups is the same.

The equivocality scale previously used for H.6 was converted to the nominal scale, low vs. high equivocality, by using the scale's lower and upper quartile range limits, that is, categorizing the interval equivocality scale to

stratify the groups. The same media and effectiveness scales used in H. 7 were applied here, and the method similarly compares the result to a Z' table to accept or reject the null hypothesis.

4.12.9 Hypothesis 9

H. 9: Effectiveness is positively related to media use when the medium is matched to task characteristics.

As discussed in Part 2, task characteristics refer to the extent to which work processes are analyzable or unanalyzable. The IP model hypothesizes that the appropriate communication methods for unanalyzable tasks involve the use of rich media because as tasks become less analyzable (implying greater difficulty in formulating standard measures to apply to problems), equivocality tends to increase, so individuals will be more likely to favor using information-rich media (Blandin & Brown, 1977; Randolph & Finch, 1977; Rice, 1992; Tushman & Nadler, 1978; Van de Ven et al., 1976; Zmud et al., 1990).

Consequently, this analysis extends the hypothesis testing from the use of lean media in H. 7 and H. 8 to the use of rich media in order to match task characteristics. When the groups are stratified by analyzability as they were in the previous tests, the analysis tested the hypothesis that in the low analyzability group, use of rich media would correlate more highly with effectiveness than it would in the high analyzability group.

The hypothesis tests are the same as those undertaken in H. 7, with the exception that in this analysis the significance tests on the differences of the Z' transformations extend to the correlations between effectiveness and use of

rich media. A new scale included for tests involving rich media is explained more fully in Part 5. Essentially, its development followed the same procedures as were used to develop the scale for lean media: items on media use from questions 12–15 were tested with the KMO measure for sampling adequacy, and (PC) factor analysis was used to identify discrete factors and assess item loadings with respect to media richness. The new scales were examined with scale alpha to assess reliability. These results and factor loadings are provided and detailed in Part 5, but essentially, the PC analysis extracted three principal components for rich media:

1) group meetings and use of liaisons;
2) face-to-face and telephone conversations;
3) voice mail.

Note that the factor extraction combined the two variables of group meetings and use of liaisons into a single principal component, and it also combined the variables of face-to-face communication and telephone conversations into one principal component. Voice mail was extracted as a single factor.

4.12.10 Hypothesis 10

H. 10: Effectiveness is negatively related to media use when the medium is not matched to task characteristics.

This test is a reverse of the tests applied in H. 9. This analysis tested the hypothesis that in the high analyzability group, use of rich media will have a lower correlation with effectiveness than in the low analyzability group because the use of rich media does not match the model's prediction that rich media is more useful in low analyzability environments.

The strategy involved in correlating usage and performance components within stratified groups also relied on the same methods for testing H. 9: results were analyzed to identify the correlations between effectiveness and media use and then examined for the difference between groups by applying significance tests on the differences of the Z' transformations of the correlations. The same scales previously used for H. 9 were also applied here.

4.13 Collection and Analysis of Qualitative Data

4.13.1 Introduction

As indicated previously, this study employed a combination of research methods, including both the quantitative survey instrument as well as qualitative methods in the form of semi-directed telephone interviews to a small subset of the original AIAA subjects and a face-to-face meeting with other members of the AIAA. Such an approach is consistent with the triangulation strategy of Denzin (1970b).

The specific questions for the qualitative survey were in part determined by the responses obtained on the quantitative questionnaires and by recommendations offered by Groves and Kahn (1979) in their research on telephone survey methods. The telephone survey had two goals: first, to enhance understanding of trends that were indicated in the quantitative questionnaires; second, to use the follow-up survey as a way to discover information found in the quantitative section that may not be indicated as clearly as is desirable for analytic purposes.

4.13.2 Triangulation

This study included the quantitative questionnaire approach and semi-directed telephone interviews for purposes of triangulation (Webb and others, 1981). The triangulated approach has two principal advantages. First, it can assess convergent validation insofar as one may design the procedures in the attempt to obtain information about the same variables or concepts from more than one other procedure (Albrecht & Ropp, 1982; Goetz, 1965). Secondly, a triangulated methodology permitted the researcher to employ one procedure to compensate for limitations of another. In this case, the quantitative survey provided the benefit of collecting opinions from a large sample more efficiently and rendered the data more easily amenable to statistical analyses.

The disadvantage of the quantitative survey instrument, that is, that it limited the responses that the subjects may give, could be offset by the interview which provided subjects with the opportunity to voice opinions in greater detail (Albrecht & Ropp, 1982; Denzin, 1970b). However, the interview had the disadvantages of taking a great deal of time to administer and in generating interest among potential subjects to participate in a telephone interview. That is, if a subject could be reached, either the individual had already sent in the survey and felt there was nothing more to add or that individual did not send it in because they did not use computers and felt that it was not applicable. Thus, the sample size for the interview is relatively small; nevertheless, by using both surveys and semi-directed interviews, the researcher was able to accrue the advantages of both

procedures while at the same time endeavoring to compensate for the shortcomings of each.

Because the mailing of the surveys and subsequent data input were handled exclusively by the Center for Survey Research in Indiana to ensure participant confidentiality, no identifications of respondents were made available to the author at the conclusion of the data entry. However, the author was able to use a random number table to generate a subset list of subjects to contact by telephone by using the original list of subjects for the study from the data base of names provided by the AIAA.

After obtaining a list of names, the method to locate the individuals relied on using regional phone directories. If the person could be contacted, the first step was an introduction by the researcher who explained the purpose of the call as it related to the study. (See Appendix F for the text of this protocol.) If the subject agreed to continue, the following five questions comprised the opening remarks of the semi-directed interview, in the expectation of engaging the subject's further participation:

1. Do you remember filling out a survey on computer networks this summer?

   (Memory jogs if needed: survey printed on blue paper; sent in a NASA envelope; had two cover letters.)

2. Do you recall at the time what your general impression was of the survey? (Favorable or unfavorable?) Why?

3. One of our main goals was to examine the use of computer networks to share or obtain information. Do you personally use computer networks for these purposes?

A) If not, why not?

B) If so, in what specific ways do you use them? Why?

C) Would you prefer to use networks more or less of the time than you do now? Why?

4. One of the findings of the study seemed to indicate that computer networks are not used as often as we expected. That is, about 30% of the people accounted for 80% of the use. Does that surprise you? If so, (if not), why?

5. Do you have any other comments or questions about the study or the use of networks?

Use of a five-item protocol is consistent with the research of Groves and Kahn (1979) who reported the tendencies of both shorter, more truncated answers over the telephone and sharp drop-off rates of participation when more than five problems were initially proposed to the subjects. Discussion of the results is given in Part 5.

REFERENCES CITED IN PART 4

Albrecht, T. L., & Ropp, V. (1982). The study of network structuring in organizations through the use of method triangulation. The Western Journal of Speech Communication, 46, 162–178.

Babbie, E. R. (1979). The practice of social research (2nd ed.). Belmont, CA: Wadsworth.

Balaguer, N. S. (1988). CIM information technology utilization and organizational design: A field study on information processing. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Blalock, H. M. (1979). Social statistics (2nd ed.). New York: McGraw-Hill.

Blandin, J. S., & Brown, W. B. (1977). Uncertainty and management's search for information. IEEE transactions on Engineering Management, EM–24, 114–119.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. Psychometrika, 16, 297–334.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. Management Science, 32, 554–571.

Daft, R. L., & Macintosh, N. B. (1981). A tentative exploration into the amount and equivocality of information processing in organizational work units. Administrative Science Quarterly, 26, 207–224.

Daft, R. L., & Weick, K. E. (1984). Toward a model of organizations as interpretation systems. Academy of Management Review, 9, 284–295.

Denzin, N. K. (1970a). Sociological methods: A sourcebook. Chicago: Aldine.

Denzin, N. K. (1970b). The research act: A theoretical introduction to sociological methods. Chicago: Aldine.

Dillman, D. A. (1978). Mail and telephone surveys: The total design method. New York: Wiley.

Downey, H. K., Hellriegel, D., & Slocum, J. R., Jr. (1975). Environmental uncertainty: The construct and the application. Administrative Science Quarterly, 20, 613–629.

Ferguson, G. A. (1981). Statistical analysis in psychology and education (5th ed.). New York: McGraw-Hill.

Groves, R. M., & Kahn, R. L. (1979). Surveys by telephone. New York: Academic Press.

Kaiser, H. F. (1974). An index of factorial simplicity. Psychometrika, 39, 31–36.

Kennedy, J. (November 27, 1993). Subject: Book outline. E-mail message.

Kleinbaum, D. G., & Kupper, L. L. (1978). Applied regression analysis and other multivariable methods. North Scituate, MA: Duxbury Press.

Leifer, R., & Triscari, T. (1987). Organizational information processing characteristics and computer based information systems design (Working paper), School of Management, Rensselaer Polytechnic Institute, Troy, NY.

Lissitz, R. W., & Green, S. B. (1975). Effect of the number of scale points on reliability. Journal of Applied Psychology, 60(1), 10–13.

McDonough III, E. F., & Leifer, R. (1983). Using simultaneous structures to cope with uncertainty. Academy of Management Journal, 26, 727–735.

Mintzberg, H. (1983). Structure in fives: Designing effective organizations. Englewood Cliffs, NJ: Prentice-Hall.

Norušis, M. J. (1990). SPSS Base system user's guide (4th ed.). Chicago: SPSS, Inc.

O'Reilly, C. A. (1982). Variations in decision makers' use of information sources: The impact of quality and accessibility of information. Academy of Management Journal, 25, 756–771.

Randolph, W., & Finch, F. (1977). The relationship between organizational technology and the direction and frequency dimensions of task communications. Human Relations, 30, 1131–1145.

Rice, R. E. (1992). Task analyzability, use of new media, and effectiveness: A multi-site exploration of media richness. Organization Science, 3(4), 475–500.

Rummel, R. J. (1970). Applied factor analysis. Evanston, IL: Northwestern University Press.

Siegel, S. (1956). Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill.

Triscari, T. (1984). Organizations and information processing: A field study of research and development units within the United States Air Force systems command. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Tushman, M. L., & Nadler, D. A. (1978). Information processing as an integrating concept in organizational design. Academy of Management Review, 3, 613–624.

Van de Ven, A., Delbecq, A., & Koenig, R. (1976). Determinants of coordination modes within organizations. American Sociological Review, 41, 322–338.

Webb, E. T., Campbell, D. T., Schwartz, R. D., Sechrest, L., & Grove, J. B. (1981). Nonreactive measures in the social sciences (2nd ed.). Boston: Houghton Mifflin.

Weick, K. E. (1979). The social psychology of organizing (2nd ed.). Reading, MA: Addison-Wesley.

Young, R. K., & Veldman, D. J. (1981). Introductory statistics for the behavioral sciences (4th ed.). New York: Holt, Rinehart and Winston.

Zmud, R., Lind, M., & Young, F. (1990). An attribute space for organizational communication channels. Information Systems Research, 1(4), 440–457.

PART 5

RESULTS

5.1 Sampling

The data for the dissertation were collected over a five-month period from May through September of 1993 from survey questionnaires mailed to a random sample of 2,000 engineers, scientists, and other specialists who are members of the American Institute of Aeronautics and Astronautics (AIAA) and who work in occupations related directly or indirectly to aerospace R&D.

The subjects were instructed to apply the individual test items to their own task/communication environments. Subjects were not paid for participating, and an individual's decision to participate in the research was wholly voluntary. Cover letters sent with the questionnaire (samples in Appendix C) informed the subjects of the study's purpose and also explained the confidentiality policy. The mail survey yielded 1006 usable responses from aerospace workers throughout the United States. When the Survey Research Center in Indiana had completed data entry, the author received the data diskette for analysis in autumn of 1993 (summary in Appendix E).

According to Babbie (1990), in computing response rates in survey research, the accepted practice is to state the original sample size and then subtract undelivered (bad addresses, retirees, deceased subjects, etc.) questionnaires from this total. The number of completed surveys is then divided by the net sample size to obtain the net response rate. This procedure is summarized in Table 5–1 on the following page, and it indicates that the unadjusted response rate for this study was .503 percent, and net the response rate was .552 percent.

Table 5–1

SURVEY RESPONSE RATE STATISTICS

Level of Analysis: Individual

Subjects	Total		Proportion
Surveys Mailed	2000		1.00
Surveys Returned	1006	Unadjusted Response Rate:	.503
Undelivered:			
Bad Address	90		.045
Not Applicable	46		.023
Retired	38		.019
Deceased	5		.003
Undelivered Total	179		.090
Net Sample Size (Mailed minus undelivered)	1821	**NET RESPONSE RATE:**	**.552**

5.2 Hypothesis Testing

Described below are the results of the tests performed on the ten hypotheses given in Part 3. The findings are organized separately under the individual hypotheses. However, data indicating the number of valid cases, scales' means, standard deviations, and alpha coefficients are summarized in Tables 5–2 and 5–3.

Of the ten hypotheses proposed in this study, three hypotheses (H. 2, H.3, and H. 5) were supported with statistical significance of $p \leq .01$ or better. Another hypothesis (H. 1) had statistical significance of $p \leq .01$, but it was in the opposite direction from what was predicted. The remaining hypotheses (H. 4 and H. 6 through H. 10) were not supported. An explanation of the results for each hypothesis is provided in the ten sections below. A summary table of all ten hypotheses and their results is provided in Table 5–26.

5.2.1 Hypothesis 1

H. 1: The greater the degree of task variety, the greater the amount of perceived uncertainty.

To test H. 1 empirically, a *t*-test of independent means was applied to test the null hypothesis that there would be no difference in the amounts of perceived uncertainty between the high and low task variety groups. As explained in Part 4, the first step in this analysis computed the item correlation matrices for both variable sets of variety and uncertainty to assess the extent to which the individual scale items correlated with one another. All of the items' correlations in both matrices had significance levels less than or equal to .01. Intra-variable correlation matrices are provided in Table 5–4.

Table 5–2

SURVEY SUMMARY STATISTICS

Contextual Variables

Level of Analysis: Individual

(N = 1006)

Scale	No. of Items	Valid Cases	Mean	S.D.	Alpha
Variety	4	1004	15.34	2.71	.66
Analyzability	4	1004	11.08	3.36	.79
Uncertainty	5	1003	12.98	3.39	.68
Equivocality	6	1003	22.58	3.95	.78
Effectiveness	8	984	32.26	4.10	.82

Table 5–3

SURVEY SUMMARY STATISTICS

Media Scales

Level of Analysis: Individual

(N = 1006)

Scale	No. of Items	Valid Cases	Mean	S.D.	Alpha
LEAN1 (Electronic Mail)	4	976	5.15	4.29	.91
LEAN2 (Written Documents)	5	989	5.54	3.85	.80
RICH1 (Group Meetings & Liaisons)	8	990	11.76	6.67	.89
RICH2 (Face-to-Face & Telephone)	7	992	10.45	5.89	.88
RICH3 (Voice Mail)	2	947	2.57	2.32	.83
Hours of CMC Use (Average Number per Week)	1	978	8.59	11.84	N/A
CMC Messages to Other Organizations (Average Number per Week)	1	756	3.01	7.13	N/A

Table 5-4

INTRA-VARIABLE CORRELATION MATRICES

Variety and Uncertainty

Variable	Variety			
	VAR1	VAR2	VAR3	VAR4
VAR1	1.00	.35**	.43**	.31**
VAR2	.35**	1.00	.27**	.36**
VAR3	.43**	.27**	1.00	.22**
VAR4	.31**	.36**	.22**	1.00

Variable	Uncertainty				
	UNCER1	UNCER2	UNCER3	UNCER4	UNCER5
UNCER1	1.00	.35**	.10**	.35**	.23**
UNCER2	.35**	1.00	.26**	.28**	.43**
UNCER3	.10**	.26**	1.00	.21**	.33**
UNCER4	.35**	.28**	.21**	1.00	.39**
UNCER5	.23**	.43**	.33**	.39**	1.00

* - Signif. LE .05   ** - Signif. LE .01   (2-tailed)

The reliability analysis, scale alpha, using the covariance matrix was applied to both scales, and the results are summarized in Tables 5–5 and 5–6. The alpha coefficient for variety was .66, and the alpha coefficient for uncertainty was .68; these results yield a good degree of confidence in the items' scales (Nunnally, 1978). The scales were also assessed with the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1974). The KMO measure for variety was .69, and for uncertainty was .71; Kaiser stated that KMO measures above .50 were "acceptable" for research, that measures above .60 were "very good," and that measures above .70 were "meritorious." Thus, we may have a good level of confidence in the sampling adequacy before using factor analysis.

The principal-components (PC) factor analysis using varimax rotation extracted two separate factors, variety and uncertainty, and both satisfied the eigenvalue criterion with eigenvalues over 1 (Kim & Mueller, 1978). The four survey items for variety were coded as VAR1 through VAR4, and the five items for uncertainty were coded as UNCER1 through UNCER5. Results are given in Table 5–7. Also, normal probability (P–P) plots were computed to assess the overall sampling distributions, and the results of the plots are illustrated in Figures 5–1 and 5–2. The relatively straight lines of the plots indicate normal distributions (Norušis, 1990).

Tests for linearity indicated that there is no curvilinear relation between the variables. Specifically, in Figure 5–3 where the studentized residuals are plotted against the predicted values, the random distribution of the points in a band around 0 indicates the assumption of linearity is met (Norušis, 1990). The histogram in Figure 5–4 shows slight asymmetry

Table 5–5

RELIABILITY ANALYSIS

Variety

R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

***** METHOD 2 (COVARIANCE MATRIX) WILL BE USED FOR THIS ANALYSIS *****

1. VAR1 Task variety-Item1
2. VAR2 Task variety-Item2
3. VAR3 Task variety-Item3
4. VAR4 Task variety-Item4

OF CASES = 996.0

ITEM-TOTAL STATISTICS

	SCALE MEAN IF ITEM DELETED	SCALE VARIANCE IF ITEM DELETED	CORRECTED ITEM-TOTAL CORRELATION	SQUARED MULTIPLE CORRELATION	ALPHA IF ITEM DELETED
VAR1	11.45	4.16	.52	.28	.53
VAR2	11.77	4.29	.44	.21	.59
VAR3	11.96	4.40	.42	.21	.60
VAR4	10.92	5.39	.39	.17	.62

RELIABILITY COEFFICIENTS 4 ITEMS

ALPHA = .66 STANDARDIZED ITEM ALPHA = .66

Table 5-6

RELIABILITY ANALYSIS

Uncertainty

R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

***** METHOD 2 (COVARIANCE MATRIX) WILL BE USED FOR THIS ANALYSIS *****

1.	UNCER1	Uncertainty-Item1
2.	UNCER2	Uncertainty-Item2
3.	UNCER3	Uncertainty-Item3
4.	UNCER4	Uncertainty-Item4
5.	UNCER5	Uncertainty-Item5

OF CASES = 974.0

ITEM-TOTAL STATISTICS

	SCALE MEAN IF ITEM DELETED	SCALE VARIANCE IF ITEM DELETED	CORRECTED ITEM-TOTAL CORRELATION	SQUARED MULTIPLE CORRELATION	ALPHA IF ITEM DELETED
UNCER1	10.54	7.69	.38	.19	.65
UNCER2	10.25	6.67	.49	.27	.60
UNCER3	10.18	8.18	.32	.13	.67
UNCER4	10.75	7.20	.45	.23	.62
UNCER5	10.88	6.79	.52	.30	.59

RELIABILITY COEFFICIENTS 5 ITEMS

ALPHA = .68 STANDARDIZED ITEM ALPHA = .67

Table 5–7

FACTOR ANALYSIS

Variety and Uncertainty

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
VAR1	.58	*	1	2.39	26.5	26.5
VAR2	.50	*	2	1.83	20.4	46.9
VAR3	.45	*				
VAR4	.42	*				
UNCER1	.35	*				
UNCER2	.52	*				
UNCER3	.35	*				
UNCER4	.48	*				
UNCER5	.57	*				

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

VARIMAX CONVERGED IN 3 ITERATIONS.

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2
UNCER5	.74	
UNCER2	.72	
UNCER4	.67	
UNCER1	.59	
UNCER3	.57	
VAR1		.76
VAR2		.71
VAR3		.67
VAR4		.64

Figure 5-1
Normal Probability (P-P) Plots for Variety and Analyzability

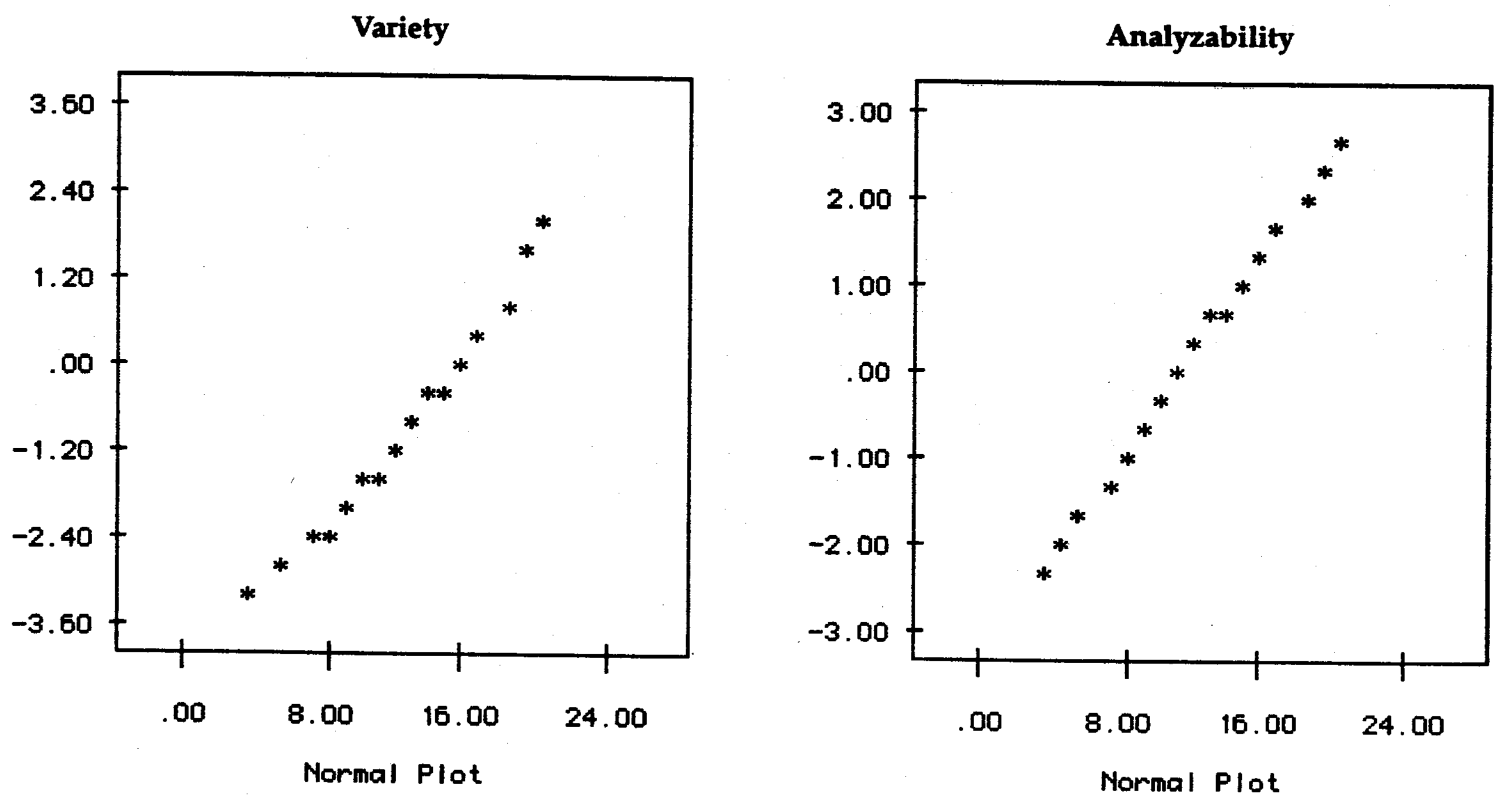


Figure 5–2
Normal Probability (P-P) Plots for Uncertainty and Equivocality

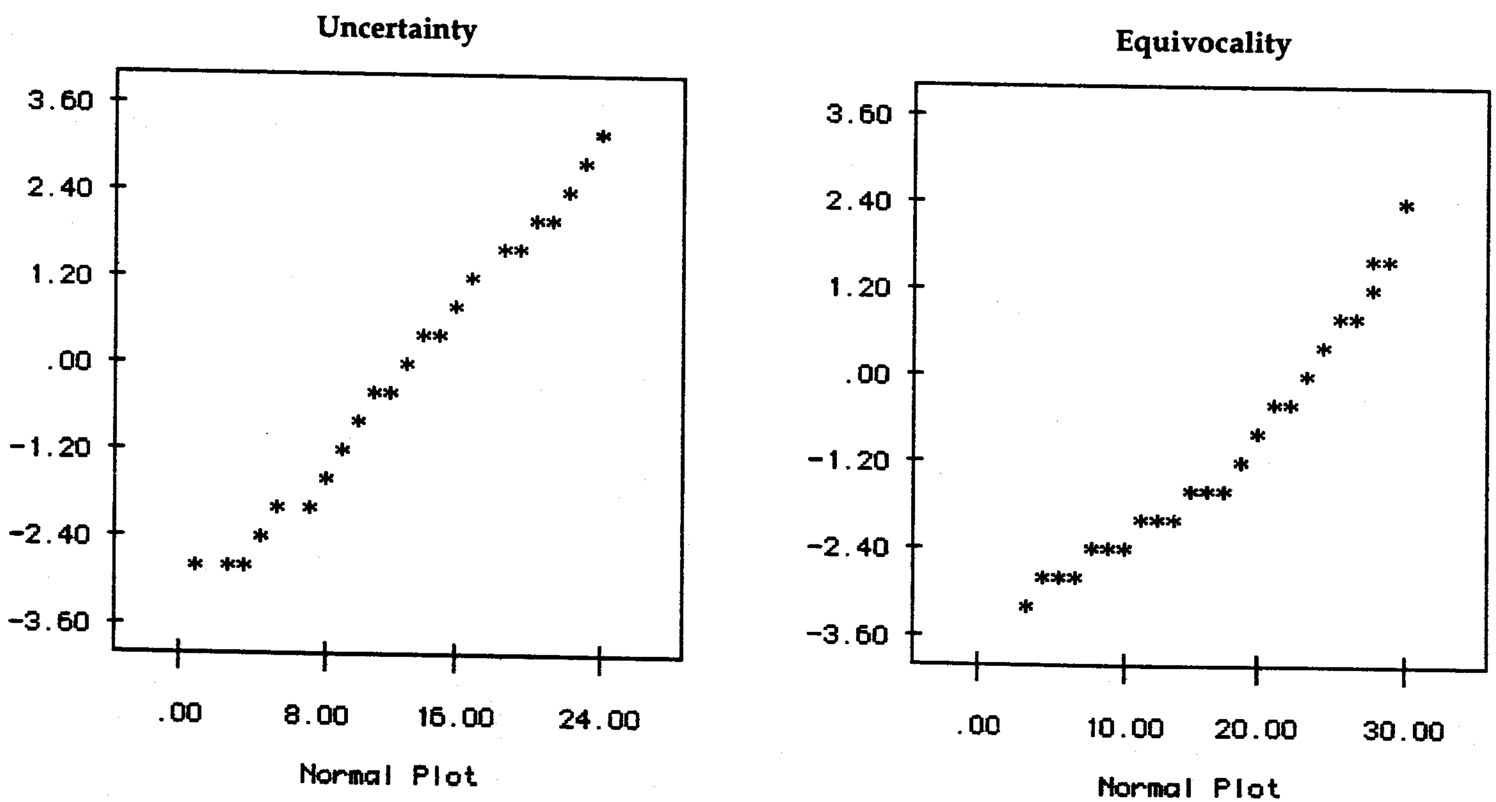


Figure 5–3
Standardized Scatterplot for Uncertainty and Variety (H. 1)

Predicted Values (*PRED)
Plotted Against
Studentized Residuals (*RESID)

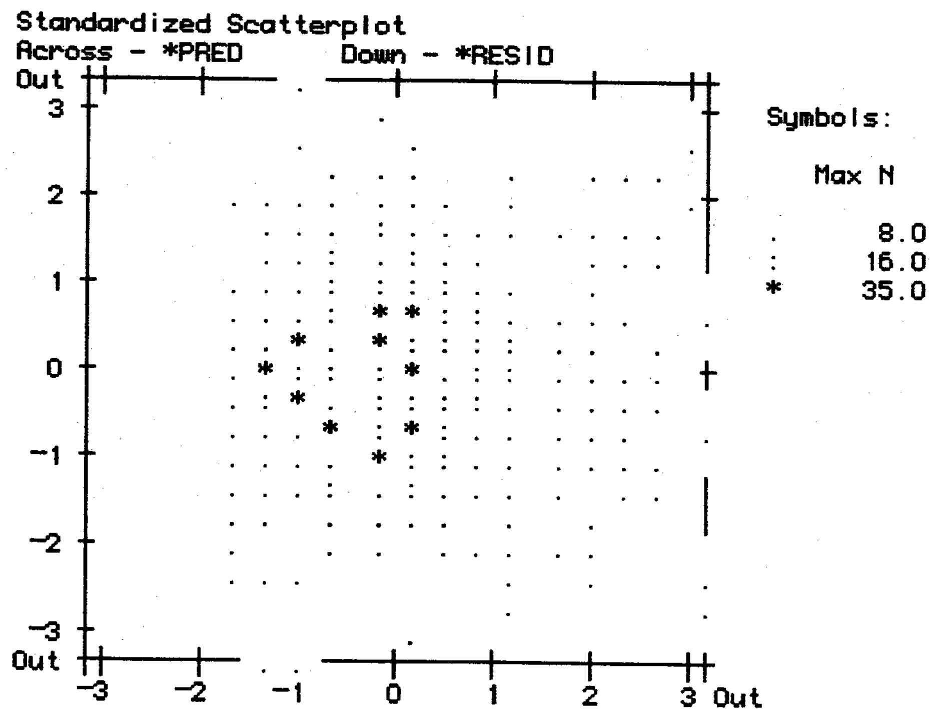


Figure 5–4
Standardized Scatterplot for Uncertainty and Variety (H.1)

Histogram of Studentized Residuals

```
Histogram - Studentized Residual

  N  Exp N      (* = 3 Cases,     . : = Normal Curve)
  1     .77   Out
  1    1.54  3.00 .
  5    3.92  2.67 :*
 10    8.95  2.33 **:
 22   18.30  2.00 *****:*
 37   33.53  1.67 ***********:*
 50   55.03  1.33 *****************.
 80   80.90  1.00 ***************************:
103  106.53   .67 **********************************
121  125.65   .33 ****************************************
126  132.76   .00 ******************************************
125  125.65  -.33 *****************************************:
121  106.53  -.67 ***********************************:****
 89   80.90 -1.00 ***************************:***
 58   55.03 -1.33 ******************:*
 25   33.53 -1.67 ********  .
 17   18.30 -2.00 *****:
  7    8.95 -2.33 **.
  2    3.92 -2.67 :
  1    1.54 -3.00 .
  2     .77   Out *
```

with more positive than negative studentized residuals and more extreme residuals than we might expect from a normal distribution, but overall this distribution is fairly evenly balanced, so the residuals, while not quite normal, are not too far off, again suggesting no curvilinear effect (Norušis, 1990).

The literature discusses contextual variables (i.e., variety, analyzability, etc.) in terms of low and high ranges; therefore, the low and high quartiles for variety were calculated to divide the sample into low and high task variety groups. The low quartile range for variety consisted of scores less than or equal to 14; the high quartile range for variety included scores greater than or equal to 17. The t-test of independent means was applied to test the null hypothesis that there would be no difference in the amounts of perceived uncertainty between the low (N = 329) and high (N = 348) variety groups.

The results of the t-test indicated that findings were exactly opposite to what was predicted (see Table 5–8). Instead of finding higher levels of uncertainty in high variety environments, the t-test showed that subjects in low variety environments experience slightly more uncertainty than do the subjects in high variety environments. The finding is significant at $p \leq .01$ level, but this is likely due to the sample size. Post hoc analysis of the possible reasons for the finding are given in Part 6, Discussion and Conclusion.

RESULT: H. 1 is not supported.

5.2.2 Hypothesis 2

H. 2: The greater the degree of task analyzability, the less the amount of perceived uncertainty.

Table 5–8

t-TEST OF INDEPENDENT MEANS

H. 1 on Variety and Uncertainty

t-tests for independent samples of NEWVAR

GROUP 1 - LOWVAR EQ 1.00
GROUP 2 - HIVAR EQ 2.00

Variable	Number of Cases	Mean	Standard Deviation	Standard Error
UNCERSET Overall Uncertainty				
GROUP 1	329	13.23	3.37	.19
GROUP 2	348	12.53	3.37	.18

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-tail Prob.	t Value	Degrees of Freedom	2-tail Prob.	t Value	Degrees of Freedom	2-tail Prob.
1.00	.98	2.70	675	.01	2.70	672.78	.01

The *t*-test applied to H. 2 found that there was a statistically significant difference in the amounts of perceived uncertainty between low and high task analyzability groups. The correlation matrix for analyzability is given in Table 5–9. All of the correlations had intra-variable significance levels less than or equal to .01.

The reliability analysis, scale alpha, using the covariance matrix was applied to the analyzability scale, and the results are summarized in Table 5–10. The alpha coefficient for analyzability was .79; this result yields a high degree of confidence in the item scale (Nunnally, 1978). The scale was also assessed by the KMO test for sampling adequacy (Kaiser, 1974). The KMO measure for analyzability was .69, a very good confidence level for sampling adequacy before using factor analysis.

The principal-components (PC) factor analysis using varimax rotation extracted two factors, analyzability and uncertainty, and both satisfied the eigenvalue criterion by having eigenvalues over 1 (Kim & Mueller, 1978). Results are given in Table 5–11. Also, a normal probability (P–P) plot was computed to assess the overall sampling distribution of analyzability; the result of the plot was previously illustrated in Figure 5–1. The relatively straight line of the plot indicates a normal distribution (Norušis, 1990).

Low and high quartile ranges for analyzability were calculated to divide the sample into low and high groups. The low quartile range for analyzability consisted of scores less than or equal to 9; the high quartile range for analyzability included scores greater than or equal to 14. The *t*-test was applied to test the null hypothesis that there would be no difference in the amounts of perceived uncertainty between low (N = 347) and high (N = 258)

Table 5–9

INTRA-VARIABLE CORRELATION MATRICES

Analyzability and Equivocality

Variable	Analyzability			
	ANA1	ANA2	ANA3	ANA4
ANA1	1.00	.48**	.49**	.47**
ANA2	.48**	1.00	.34**	.36**
ANA3	.49**	.34**	1.00	.77**
ANA4	.47**	.36**	.77**	1.00

Variable	Equivocality					
	EQUIV1	EQUIV2	EQUIV3	EQUIV4	EQUIV5	EQUIV6
EQUIV1	1.00	.49**	.54**	.29**	.24**	.38**
EQUIV2	.49**	1.00	.49**	.26**	.31**	.27**
EQUIV3	.54**	.49**	1.00	.27**	.27**	.39**
EQUIV4	.29**	.26**	.27**	1.00	.42**	.48**
EQUIV5	.24**	.31**	.27**	.42**	1.00	.38**
EQUIV6	.38**	.27**	.39**	.48**	.38**	1.00

* - Signif. LE .05 ** - Signif. LE .01 (2-tailed)

Table 5–10

RELIABILITY ANALYSIS

Analyzability

R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

***** METHOD 2 (COVARIANCE MATRIX) WILL BE USED FOR THIS ANALYSIS *****

1.	ANA1	Analyzability-Item1
2.	ANA2	Analyzability-Item2
3.	ANA3	Analyzability-Item3
4.	ANA4	Analyzability-Item4

OF CASES = 994.0

ITEM-TOTAL STATISTICS

	SCALE MEAN IF ITEM DELETED	SCALE VARIANCE IF ITEM DELETED	CORRECTED ITEM-TOTAL CORRELATION	SQUARED MULTIPLE CORRELATION	ALPHA IF ITEM DELETED
ANA1	8.37	6.83	.59	.36	.74
ANA2	8.22	7.42	.46	.25	.80
ANA3	8.35	6.38	.68	.62	.70
ANA4	8.37	6.52	.67	.61	.70

RELIABILITY COEFFICIENTS   4 ITEMS

ALPHA = .79   STANDARDIZED ITEM ALPHA = .79

Table 5–11

FACTOR ANALYSIS

Analyzability and Uncertainty

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
ANA1	.58	*	1	2.84	31.6	31.6
ANA2	.43	*	2	1.86	20.7	52.3
ANA3	.72	*				
ANA4	.71	*				
UNCER1	.37	*				
UNCER2	.53	*				
UNCER3	.32	*				
UNCER4	.50	*				
UNCER5	.55	*				

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

VARIMAX CONVERGED IN 3 ITERATIONS.

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2
ANA3	.84	
ANA4	.84	
ANA1	.76	
ANA2	.65	
UNCER5		.74
UNCER2		.72
UNCER4		.71
UNCER1		.61
UNCER3	-.30	.47

analyzability groups. The results of the *t*-test (see Table 5–12) confirmed at the $p \leq .0001$ level that the null hypothesis should be rejected.

RESULT: H. 2 has statistical support.

5.2.3 Hypothesis 3

H. 3: The greater the amount of uncertainty, the greater the use of CMC.

The uncertainty scale used to test H. 1 and H. 2 was also applied in the test of H. 3. The CMC variable was measured by question 19 in the survey instrument which asked employees to indicate the approximate number of hours that they used job-related CMC in a typical past work week.

The scatterplots of studentized residuals that were applied to assess the sampling distribution of the reported hours of CMC use are illustrated in Figures 5–5 and 5–6, and they indicate departure from the normal distribution. As explained in the previous chapter, if the distribution departs from normality, some researchers favor using a nonparametric or distribution-free test that makes no assumption of normality of the population parameters (Glass, Peckham, & Sanders, 1972). On the other hand, there are theorists who argue that the *t*-test is robust and operates well even under violation assumptions, provided that such violations are not gross and multiple (Bradley, 1972; Kerlinger, 1986).

This analysis applies the more cautious approach, suggesting that the use of the *t*-test alone is probably inadvisable in this case due to possible violations of the *t*-test's assumption of a normal distribution; therefore, the nonparametric Mann-Whitney *U* test was applied to H. 3 to test the null

Table 5–12

t-TEST OF INDEPENDENT MEANS

H. 2 on Analyzability and Uncertainty

t-tests for independent samples of NEWANA

GROUP 1 - LOWANA EQ 1.00
GROUP 2 - HIANA EQ 2.00

Variable	Number of Cases	Mean	Standard Deviation	Standard Error
UNCERSET Overall Uncertainty				
GROUP 1	347	13.3545	3.692	.198
GROUP 2	258	11.9264	3.115	.194

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-tail Prob.	t Value	Degrees of Freedom	2-tail Prob.	t Value	Degrees of Freedom	2-tail Prob.
1.40	.004	5.02	603	.0001	5.15	593.38	.0001

Figure 5–5
Normal Probability (P-P) Plot of CMC Use Distribution (H.3)

Reported CMC Use

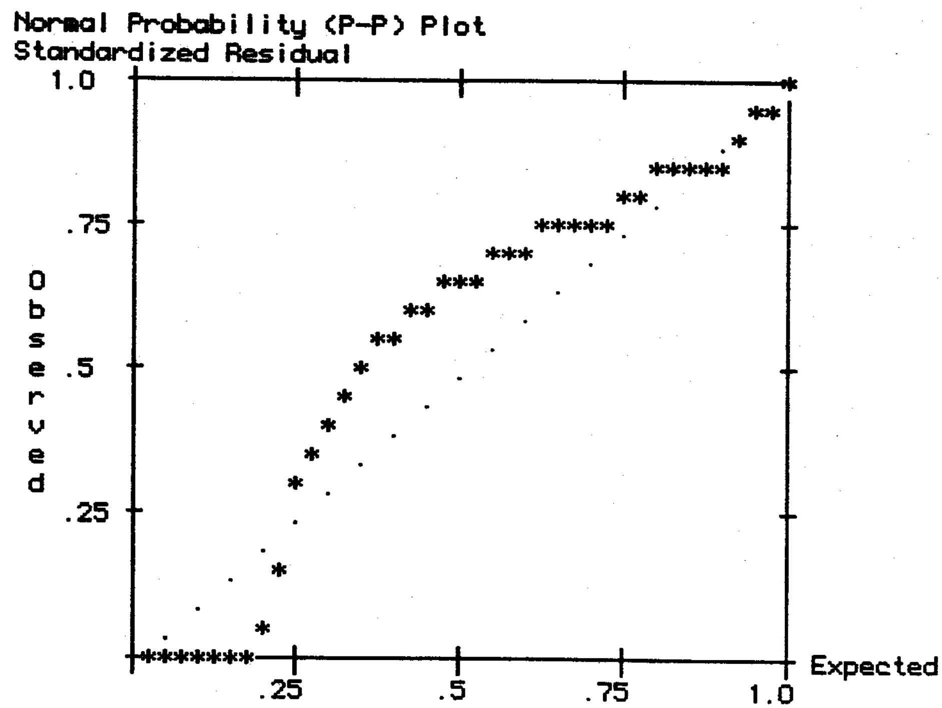


Figure 5–6
Standardized Scatterplot for Uncertainty and CMC Use (H.3)

Histogram of Studentized Residuals

```
Histogram - Studentized Residual

  N   Exp N        (* = 5 Cases,      . : = Normal Curve)
  4     .60   Out *
  2    1.19  3.00
  2    3.04  2.67 .
 26    6.93  2.33 :****
 14   14.18  2.00 **:
 35   25.98  1.67 ****:**
 27   42.63  1.33 *****    .
 25   62.67  1.00 *****         .
 53   82.52   .67 ***********         .
 46   97.34   .33 *********              .
 92  102.85   .00 ******************   .
108   97.34  -.33 ******************:***
280   82.52  -.67 ****************:***************************************
 63   62.67 -1.00 ************:
  0   42.63 -1.33         .
  0   25.98 -1.67     .
  0   14.18 -2.00  .
  0    6.93 -2.33 .
  0    3.04 -2.67 .
  0    1.19 -3.00
  0     .60   Out
```

hypothesis that there would be no difference in the amounts of CMC use between the low and high uncertainty groups. The results of the *U* test (see Table 5–13) confirmed at the $p \leq .001$ level that workers in high-uncertainty environments reported approximately one fourth more job-related CMC use (8.7 hours versus 12.0 hours per week) than did the workers in low-uncertainty environments; therefore, the null hypothesis was rejected.

RESULT: H. 3 has statistical support.

5.2.4 Hypothesis 4

H. 4: The higher the level of uncertainty, the more CMC use will extend to persons outside of the organization.

The uncertainty scale used in previous hypothesis tests was applied to test H. 4. The CMC variable was measured by question 21d in the survey instrument which asked employees to indicate the approximate number of times in a typical past work week that they used job-related CMC mechanisms to communicate with people outside of the organization. Plots computed to assess the sampling distribution of the reported amounts of CMC use are illustrated in Figures 5–7 and 5–8. They indicate sampling departs from the normal distribution. Therefore, the Mann-Whitney *U* test was applied to H. 4 to test the null hypothesis that there would be no difference in the amounts of CMC use involving workers in task environments stratified by low and high uncertainty levels.

Because the departure from normality of this sample appears to be gross, the more cautious of the two points of view is implemented in this analysis. In addition to the *t*-test, the nonparametric Mann-Whitney *U* test

Table 5-13

t-TEST OF INDEPENDENT MEANS

H. 3 on Uncertainty and CMC Use

t-tests for independent samples of NEWUNC

GROUP 1 - LOWUNC EQ 1.00
GROUP 2 - HIUNC EQ 2.00

Variable	Number of Cases	Mean	Standard Deviation	Standard Error
CMCHRS Hrs use email pr wk				
GROUP 1	266	8.7068	10.053	.616
GROUP 2	266	12.0489	12.057	.739

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-tail Prob.	t Value	Degrees of Freedom	2-tail Prob.	t Value	Degrees of Freedom	2-tail Prob.
1.44	.003	-3.47	530	.001	-3.47	513.41	.001

Table 5–14

t-TEST OF INDEPENDENT MEANS

H. 3 on Uncertainty and CMC Use

t-tests for independent samples of NEWUNC

GROUP 1 - LOWUNC EQ 1.00
GROUP 2 - HIUNC EQ 2.00

Variable	Number of Cases	Mean	Standard Deviation	Standard Error
CMCHRS Hrs use email pr wk				
GROUP 1	266	8.7068	10.053	.616
GROUP 2	266	12.0489	12.057	.739

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-tail Prob.	t Value	Degrees of Freedom	2-tail Prob.	t Value	Degrees of Freedom	2-tail Prob.
1.44	.003	-3.47	530	.001	-3.47	513.41	.001

Figure 5–7
Normal Probability (P-P) Plot of CMC Use Distribution (H.4)

Reported CMC Use Extending to Persons Outside of the Organization

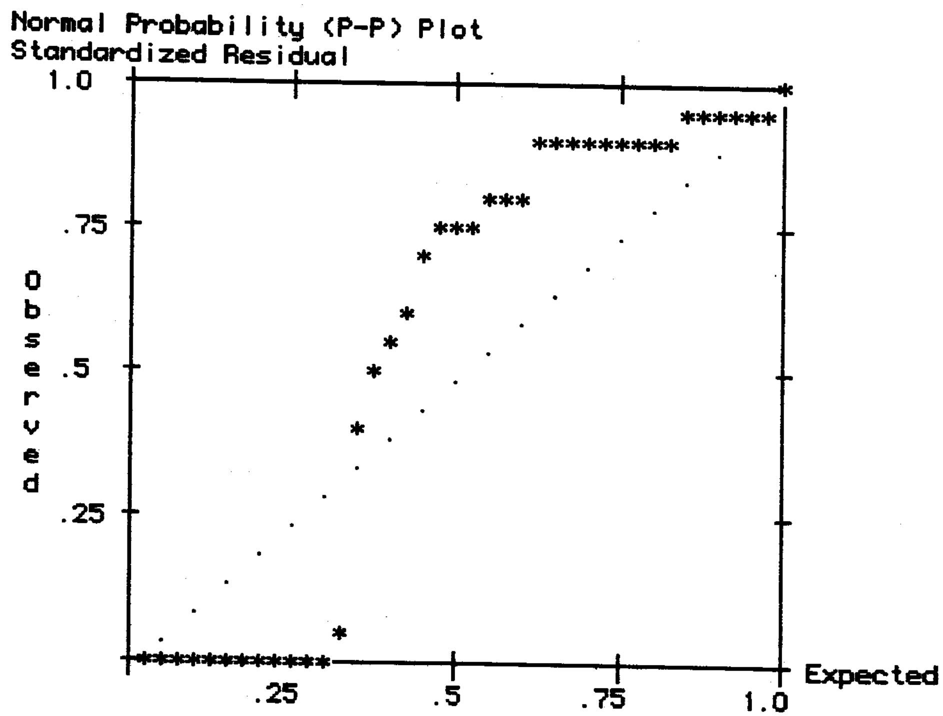


Figure 5-8
Standardized Scatterplot for Uncertainty and CMC Use Extending to Persons Outside of the Organization (H.4)

Histogram of Studentized Residuals

```
Histogram - Studentized Residual

  N   Exp N        (* = 8 Cases,      . : = Normal Curve)
 11     .58   Out *
  4    1.16  3.00 *
  0    2.95  2.67
 12    6.74  2.33 :*
  0   13.79  2.00  .
 10   25.27  1.67 * .
  3   41.48  1.33      .
 37   60.98  1.00 *****   .
  7   80.29   .67 *         .
 79   94.71   .33 **********  .
107  100.07   .00 *************:
485   94.71  -.33 ************:*************************************************
  1   80.29  -.67               .
  0   60.98 -1.00             .
  0   41.48 -1.33          .
  0   25.27 -1.67       .
  0   13.79 -2.00     .
  0    6.74 -2.33   .
  0    2.95 -2.67
  0    1.16 -3.00
  0     .58   Out
```

compares the sum of the ranks from one group with the average rank of two groups expected to be the same. The difference between the observed and expected sums is expressed in *z*-score units, and if the absolute value of the difference is greater than the critical value of $z = 2.58$, then the null hypothesis should be rejected, and it is concluded that the two groups differ (Norušis, 1990; Young & Veldman, 1981). The results of the *U* test (see Table 5–15) indicated that the absolute *z*-score of 1.18 failed to reach the critical value of 2.58. There was no significant difference in the amount of CMC use between the two groups; therefore, the null hypothesis was not rejected.

RESULT: H. 4 is not supported.

5.2.5 Hypothesis 5

H. 5: The greater the degree of analyzability, the greater the use of CMC.

The residual plots in Figures 5–9 and 5–10 indicated that the sampling distribution departed from normality, thereby suggesting the use of a nonparametric test as in the previous tests of H. 3 and H. 4. The Mann-Whitney *U* test of H. 5 confirmed a statistically significant ($p \leq .01$) difference in the predicted direction of differential amounts of CMC use between groups stratified by low and high analyzability. The analyzability scale used in the H. 2 test was also applied to test H. 5. As before, low and high quartile ranges for analyzability were calculated to divide the sample into separate groups. The CMC variable that was used to test H. 3 (approximate number of hours using CMC for job-related tasks) was also applied in this analysis.

Table 5–15

MANN-WHITNEY *U* TEST OF INDEPENDENT MEANS

H. 4 on Uncertainty and CMC Use Extending Beyond the Organization

```
- - - - - Mann-Whitney U - Wilcoxon Rank Sum W Test

   DIFORG    Num CMC to diff orgs
 by UNCERT


     Mean Rank    Cases

       264.28       257   NEWUNC = 1.00
       249.69       256   NEWUNC = 2.00
                    ----
                    513   Total

                                    Corrected for ties
          U              W              Z       2-Tailed P
      31024.5        63920.5        -1.1853        .2359
```

<u>Note</u>. A parametric *t*-test also indicated no significant difference in CMC use between groups.

Figure 5–9
Normal Probability (P-P) Plot of CMC Use Distribution (H.5)

Reported CMC Use

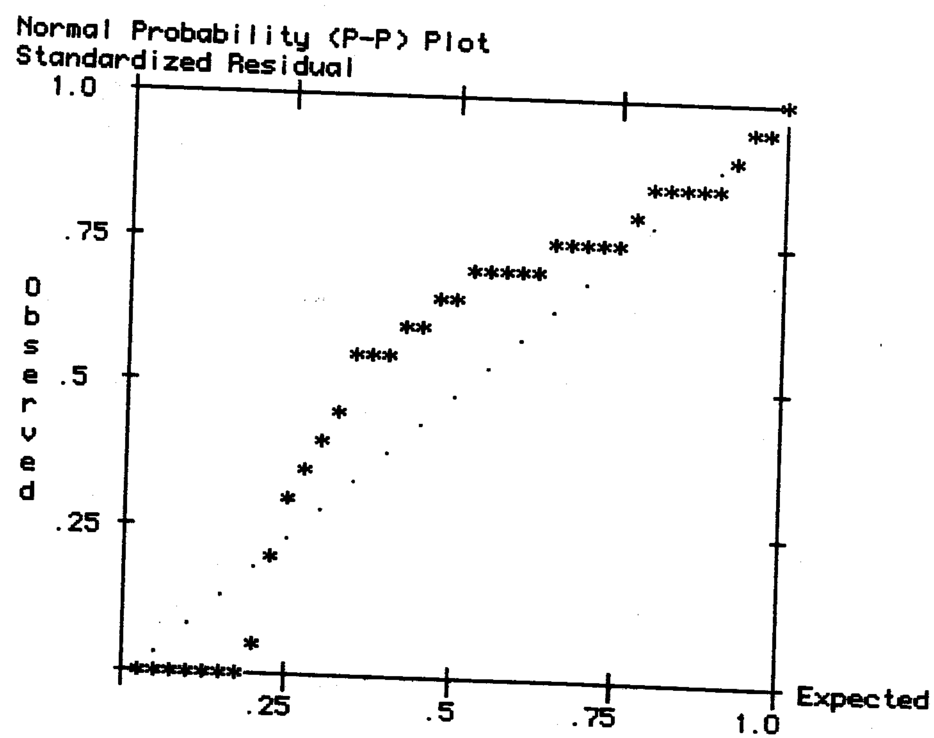


Figure 5–10
Standardized Scatterplot for Analyzability and CMC Use (H.5)

Histogram of Studentized Residuals

```
Histogram - Studentized Residual

  N  Exp N       (* = 5 Cases,      . : = Normal Curve)
  5    .60   Out *
  1   1.19  3.00
  2   3.04  2.67 .
 27   6.93  2.33 :****
 12  14.18  2.00 **.
 40  25.98  1.67 ****:***
 25  42.63  1.33 *****     .
 21  62.67  1.00 ****          .
 50  82.52   .67 **********        .
 49  97.34   .33 **********          .
 91 102.85   .00 ******************    .
115  97.34  -.33 *******************:****
298  82.52  -.67 ****************:*******************************************
 41  62.67 -1.00 ********          .
  0  42.63 -1.33              .
  0  25.98 -1.67          .
  0  14.18 -2.00       .
  0   6.93 -2.33 .
  0   3.04 -2.67 .
  0   1.19 -3.00
  0    .60   Out
```

Table 5–16 indicates that the mean CMC usage was higher among the high-analyzability group; therefore, the null hypothesis should be rejected.

RESULT: H. 5 has statistical support.

5.2.6 Hypothesis 6

H. 6: The greater the amount of perceived equivocality, the less the use of CMC.

The probability plot computed to assess the overall equivocality distribution, previously illustrated in Figure 5–2, indicated a distribution somewhat close to normal, but difficult to call with a high degree of certainty. Two other scatterplots computed for the studentized residuals, illustrated as Figures 5–11 and 5–12, indicate more clearly that the distribution departs from normality to the extent that use of a nonparametric test seems warranted (Norušis, 1990). Therefore, to test H. 6 empirically, the Mann-Whitney *U* test was applied to test the null hypothesis that there would be no difference in the amounts of reported CMC use between groups stratified by low and high degrees of equivocality.

The reliability analysis, scale alpha, using the covariance matrix was applied to the scale items, and the results are summarized in Table 5–17. The alpha coefficient was .77; these results yield a satisfactory degree of confidence for reliability (Nunnally, 1978). The equivocality scale also was assessed with the KMO measure for sampling adequacy (Kaiser, 1974), and the result was an index of .79. Thus, we have a good level of confidence in the sampling adequacy.

Table 5–16

MANN-WHITNEY *U* TEST OF INDEPENDENT MEANS

H. 5 on Analyzability and Amount of CMC Use

```
- - - - - Mann-Whitney U - Wilcoxon Rank Sum W Test

    CMCHRS     Hrs use email pr wk
  by ANALYZ


      Mean Rank     Cases

         217.00       263  LOANA = 1.00
         247.44       196  HIANA = 2.00
                     ----
                      459  Total

                                     Corrected for ties
           U              W              Z       2-Tailed P

        22356.0        48498.0        -2.4447        .01
```

Figure 5–11
Normal Probability (P-P) Plot of CMC Use Distribution (H.6)

Reported CMC Use

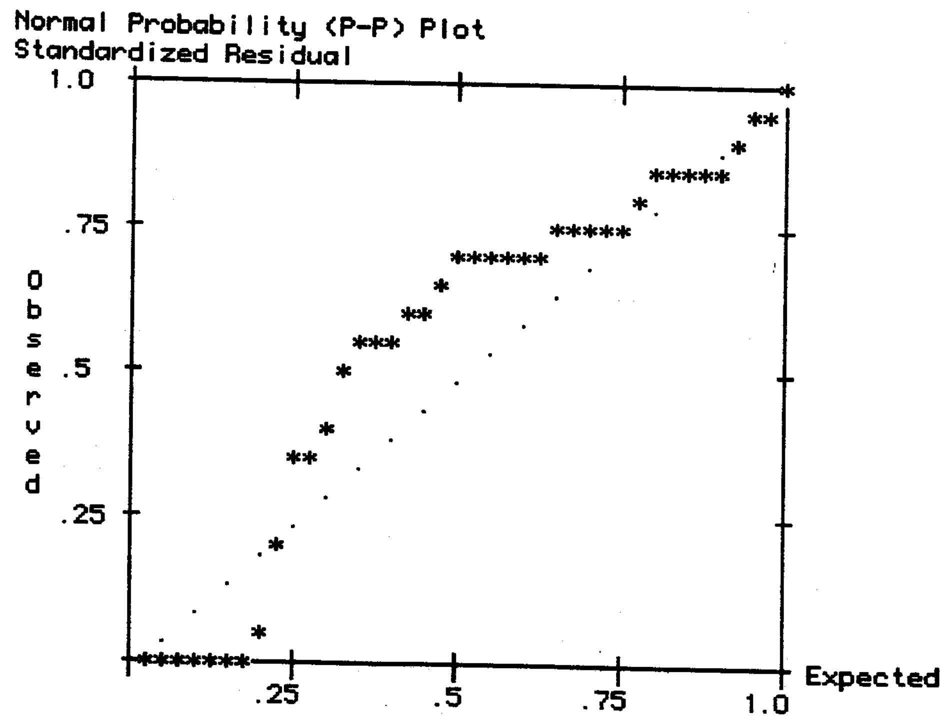


Figure 5–12
Standardized Scatterplot for Equivocality and CMC Use (H. 6)

Histogram of Studentized Residuals

```
Histogram - Studentized Residual

  N  Exp N      (* = 5 Cases,     . : = Normal Curve)
  6    .60   Out *
  0   1.19  3.00
  2   3.04  2.67 .
 27   6.93  2.33 :****
 12  14.18  2.00 **.
 47  25.98  1.67 ****:****
  9  42.63  1.33 **      .
 25  62.67  1.00 *****       .
 56  82.52   .67 ***********     .
 49  97.34   .33 **********        .
 93 102.85   .00 *******************  .
114  97.34  -.33 ******************:****
312  82.52  -.67 ****************:*********************************************
 25  62.67 -1.00 *****       .
  0  42.63 -1.33        .
  0  25.98 -1.67     .
  0  14.18 -2.00   .
  0   6.93 -2.33 .
  0   3.04 -2.67 .
  0   1.19 -3.00
  0    .60   Out
```

Table 5–17

RELIABILITY ANALYSIS

Equivocality

R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

***** METHOD 2 (COVARIANCE MATRIX) WILL BE USED FOR THIS ANALYSIS *****

1. EQUIV1 Equivocality-Item1
2. EQUIV2 Equivocality-Item2
3. EQUIV3 Equivocality-Item3
4. EQUIV4 Equivocality-Item4
5. EQUIV5 Equivocality-Item5
6. EQUIV6 Equivocality-Item6

OF CASES = 978.0

ITEM-TOTAL STATISTICS

	SCALE MEAN IF ITEM DELETED	SCALE VARIANCE IF ITEM DELETED	CORRECTED ITEM-TOTAL CORRELATION	SQUARED MULTIPLE CORRELATION	ALPHA IF ITEM DELETED
EQUIV1	19.22	8.96	.55	.38	.73
EQUIV2	18.91	9.73	.52	.33	.74
EQUIV3	19.17	8.93	.56	.39	.73
EQUIV4	19.09	9.22	.49	.31	.75
EQUIV5	18.65	9.69	.46	.25	.76
EQUIV6	19.13	8.86	.55	.34	.73

RELIABILITY COEFFICIENTS 6 ITEMS

ALPHA = .77 STANDARDIZED ITEM ALPHA = .78

The item correlation matrix for the equivocality variable to assess the extent to which the individual scale items correlated with one another was provided in Table 5–9. All of the items' correlations had significance levels less than or equal to .01. However, the principal-components (PC) factor analysis using varimax rotation extracted two factors of equivocality: task equivocality and inter-unit equivocality, and they both satisfied the eigenvalue criterion with eigenvalues over 1 (Kim & Mueller, 1978). Results are given in Table 5–18. Therefore, in this analysis low and high quartile ranges were calculated to divide the sample into low and high equivocality groups for both task and inter-unit dimensions of equivocality. The low quartile range for task equivocality consisted of scores less than or equal to 10; the high quartile range for task equivocality included scores greater than or equal to 13. The low quartile range for inter-unit equivocality consisted of scores less than or equal to 10; the high quartile range for inter-unit equivocality included scores greater than or equal to 12. The *U* tests (see Table 5–19) indicated that there were no statistically significant differences in the amount of CMC use between groups; therefore, the null hypothesis should not be rejected.

RESULT: H. 6 is not supported.

5.2.7 Hypothesis 7

H. 7: Use of information-lean media will be more strongly associated with positive effectiveness measures in analyzable environments.

Table 5–18

FACTOR ANALYSIS

Equivocality

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
INTEQ1	.68	*	1	2.83	47.2	47.2
INTEQ2	.63	*	2	1.04	17.4	64.6
INTEQ3	.69	*				
TSKEQ1	.69	*				
TSKEQ2	.58	*				
TSKEQ3	.60	*				

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.
VARIMAX CONVERGED IN 3 ITERATIONS.

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2
INTEQ1	.44	-.11
INTEQ2	.43	-.12
INTEQ3	.44	-.11
TSKEQ1	-.17	.52
TSKEQ2	-.13	.47
TSKEQ3	-.02	.39

COVARIANCE MATRIX FOR ESTIMATED REGRESSION FACTOR SCORES:

	FACTOR 1	FACTOR 2
FACTOR 1	1.00	
FACTOR 2	.00	1.00

Table 5–19

MANN-WHITNEY *U* TESTS OF INDEPENDENT MEANS

H. 6 on Task and Inter-unit Equivocality and Amount of CMC Use

```
- - - - - Mann-Whitney U - Wilcoxon Rank Sum W Test

   CMCHRS     Hrs use email pr wk
 by TASKEQV

     Mean Rank     Cases

        231.95       202  TSKEQV = 1.00
        225.76       254  TSKEQV = 2.00
                    ----
                     456  Total

                                      Corrected for ties
        U               W               Z       2-Tailed P
     24957.5         46853.5          -.50          .62
```

```
- - - - - Mann-Whitney U - Wilcoxon Rank Sum W Test

   CMCHRS     Hrs use email pr wk
 by INTR-UNITEQV

     Mean Rank     Cases

        299.83       236  INTEQV = 1.00
        310.69       376  INTEQV = 2.00
                    ----
                     612  Total

                                      Corrected for ties
        U               W               Z       2-Tailed P
     42794.0         70760.0          -.74          .46
```

Note. The parametric *t*-test also indicated no significant difference in CMC use between groups.

As explained in Part 4, Methods, this hypothesis examines the relation proposed to exist among analyzability, media use, and overall effectiveness. The analysis involves correlating usage and performance components within groups stratified by low and high degrees of analyzability. Results are tested to identify the direction and significance of each of the two correlations and the extent of the difference. The difference between the two correlations of media use and overall effectiveness is assessed by applying a test of significance on the difference of the Z' transformations (Kleinbaum & Kupper, 1978).

The media scales were developed using factor analysis techniques. Relevant questions from the survey (questions 12 a–h, 13 a–h, 14 a–h, 15 a–h) addressed the principal communication media specified on the second page of Part 3, Hypotheses: printed documents, electronic networks, telephone voice mail, telephone conversations, liaisons, face-to-face conversations, and group meetings all were entered into the factor analysis. Before applying the analysis, the items were tested with the KMO measure. It yielded a KMO index of .85 which indicates a very high level of confidence in the sampling adequacy (Kaiser, 1974).

To create the new scales for this hypothesis test, it should be noted that although the goal of factor analysis is to simplify the analysis of complex information by achieving parsimony, approximate independence, and conceptual meaningfulness among the variables, statisticians acknowledge factor analysis to be an imperfect science (Babbie, 1979; Kim & Mueller, 1978). There may not be total agreement on determining the appropriate number of factors for any given solution (Rummel, 1970).

To overcome this problem, Cattell (1966) recommended that the researcher generate a scree plot to help identify factors that account for most of the variance. A principal-components factor analysis was used to generate the scree plot illustrated in Figure 5–13.

It is apparent there are five factors we may regard as more significant than the others. After the fifth point from the left, the points begin to fall nearly horizontal to one another, suggesting that they account for very little of the variance and may be excluded from the analysis for the sake of parsimony and conceptual meaningfulness. (Adding more factors did not improve the solution.) In Figure 5–13 the five significant factors above the scree line in the plot are indicated by arrows.

The PC factor analysis using varimax rotation was then run in SPSS with the CRITERIA set to load on five factors. In this analysis, the FORMAT statement was set to include factors loading with an absolute value of .5 or more to be considered as part of the scale, a fairly standard factor criteria (Rummel, 1970). Results of the factor analysis are given in Table 5–20, and the factors are identified by their corresponding variable names in Table 5–21. The alpha coefficients for these scales' reliabilities were previously given in Table 5–3. The alpha scores of the scales ranged from .80 to .91.

Part 2, Theory, explained that a consensus of empirical research in the literature places paper and CMC media on a lean end in a scale of information richness (Balaguer, 1988; Daft & Lengel, 1986; Daft, Lengel, & Trevino, 1987; Fulk & Ryu, 1990; Lind & Zmud, 1991; Rice, 1992; Schmitz & Fulk, 1990, 1991; Short, Williams, & Christie, 1976; Trevino, Daft, & Lengel, 1990; Trevino, Lengel, & Bodensteiner, 1990; Triscari, 1984; Tyler, Bettenhausen, &

Figure 5–13
Scree Plot of Communication Media Factors

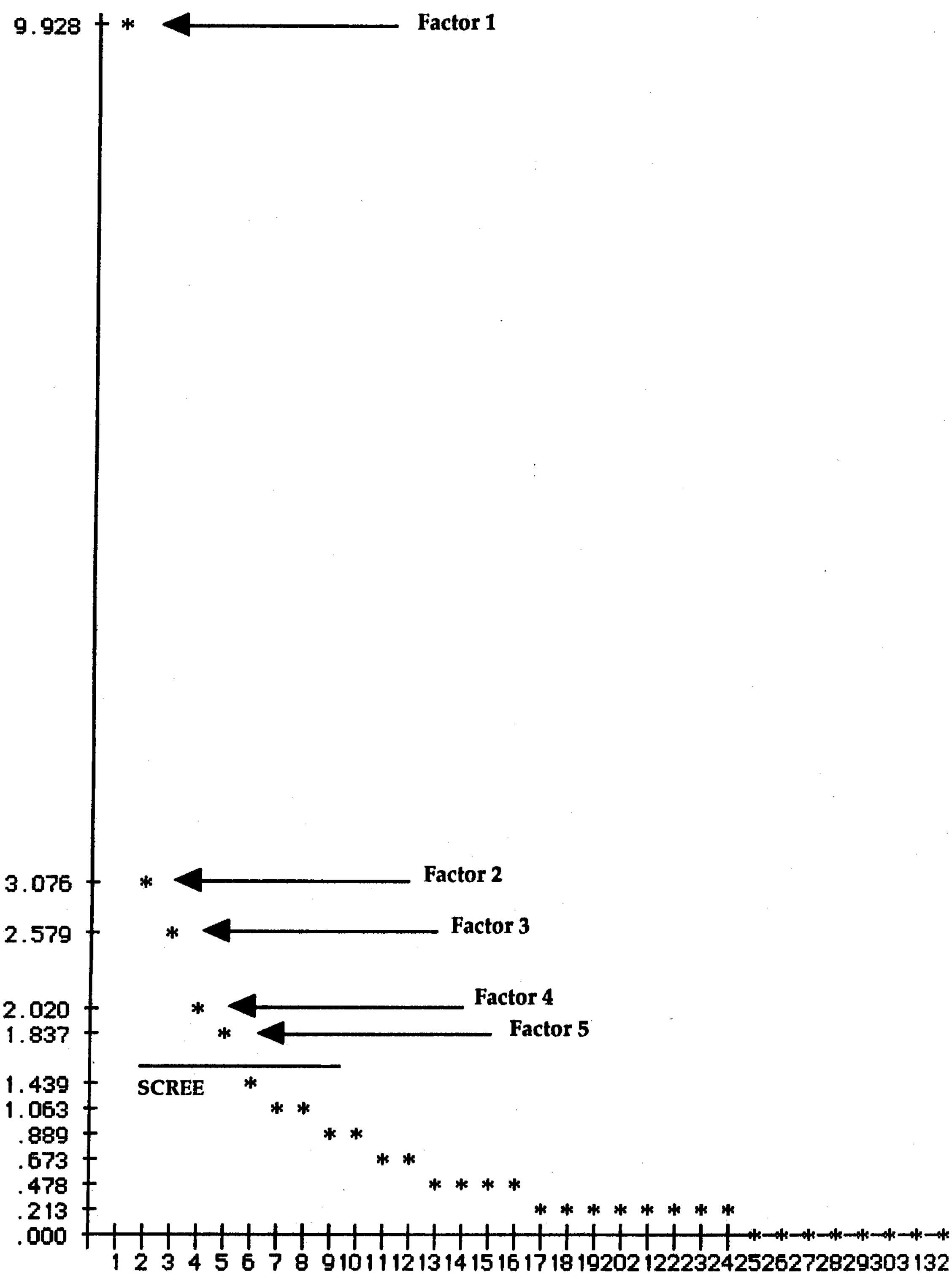


Table 5–20

FACTOR ANALYSIS

Media Variables

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
ODFTF1	.44	*	1	9.93	31.0	31.0
OOFTF1	.62	*	2	3.08	9.6	40.6
PDFTF1	.47	*	3	2.58	8.1	48.7
POFTF1	.41	*	4	2.02	6.3	55.0
ODMEET	.65	*	5	1.84	5.7	60.7
OOMEET	.77	*				
PDMEET	.73	*				
POMEET	.80	*				
ODTELCN	.43	*				
OOTELCN	.66	*				
PDTELCN	.55	*				
POTELCN	.67	*				
ODLIAS	.73	*				
OOLIAS	.65	*				
PDLIAS	.81	*				
POLIAS	.79	*				
ODVMAIL	.14	*				
OOVMAIL	.44	*				
PDVMAIL	.84	*				
POVMAIL	.86	*				
ODEMAIL	.69	*				
OOEMAIL	.77	*				
PDEMAIL	.77	*				
POEMAIL	.68	*				
OOWRIT	.44	*				
ODWRIT	.52	*				
PDWRIT	.50	*				
POWRIT	.53	*				
ODRPTS	.61	*				
OORPTS	.39	*				
PDRPTS	.60	*				
PORPTS	.46	*				

Table continued on following page

Table 5–20, Continued

FACTOR ANALYSIS

Media Variables

FINAL STATISTICS:

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

VARIMAX CONVERGED IN 6 ITERATIONS.

ROTATED FACTOR MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
POLIAS	.85				
PDLIAS	.84				
POMEET	.84				
PDMEET	.79				
ODLIAS	.78				
OOMEET	.78				
OOLIAS	.77				
ODMEET	.75				
OOTELCN		.77			
OOFTF1		.76			
POTELCN		.75			
PDFTF1		.63			
ODFTF1		.61			
PDTELCN		.58			
POFTF1		.56			
ODRPTS			.77		
PDRPTS			.76		
ODWRIT			.65		
PORPTS			.64		
OORPTS			.56		
OOEMAIL				.86	
PDEMAIL				.84	
ODEMAIL				.82	
POEMAIL				.78	
PDVMAIL					.88
POVMAIL					.85

Table continued on following page

Table 5–20, Continued

FACTOR ANALYSIS

Media Variables

FACTOR SCORE COEFFICIENT MATRIX:

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
ODFTF1	-.04	.21	.01	-.03	-.08
OOFTF1	-.02	.25	-.08	-.05	-.05
PDFTF1	-.04	.20	-.01	-.06	.00
ODMEET	.15	-.03	-.02	.02	-.03
OOMEET	.17	.02	-.09	.04	-.08
PDMEET	.16	-.03	-.00	.00	-.02
POMEET	.19	-.05	-.08	-.01	.04
ODTELCN	-.03	.15	.09	.00	-.08
OOTELCN	-.06	.27	-.06	-.01	-.06
PDTELCN	-.03	.16	.04	.00	-.01
POTELCN	-.05	.24	-.06	-.02	.00
ODLIAS	.16	-.06	.06	-.02	-.03
OOLIAS	.17	-.00	-.05	-.01	-.08
PDLIAS	.18	-.08	.03	-.03	.01
POLIAS	.18	-.07	-.01	-.04	.03
OOVMAIL	-.06	.13	-.13	.00	.19
PDVMAIL	-.02	-.09	-.02	-.04	.40
POVMAIL	-.03	-.04	-.07	-.02	.40
ODEMAIL	-.01	-.05	.06	.32	-.10
OOEMAIL	-.01	-.02	-.00	.31	-.08
PDEMAIL	-.02	-.04	.02	.30	-.01
POEMAIL	-.00	-.05	-.03	.27	.05
ODWRIT	-.03	.03	.22	.01	-.07
PDWRIT	-.03	-.02	.15	-.04	.15
POWRIT	-.02	-.03	.09	-.05	.22
ODRPTS	-.04	-.02	.33	.04	-.13
PDRPTS	-.04	-.07	.33	.00	-.03
PORPTS	-.02	-.06	.25	-.01	.02

COVARIANCE MATRIX FOR ESTIMATED REGRESSION FACTOR SCORES:

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
FACTOR 1	1.00				
FACTOR 2	.00	1.00			
FACTOR 3	.00	.00	1.00		
FACTOR 4	.00	.00	.00	1.00	
FACTOR 5	.00	.00	.00	.00	1.00

Table 5–21

FACTOR ANALYSIS

Media Variables Defined

FACTOR 1:	**Group Meetings and Liaisons**
POLIAS	Provide information to other departments via liaisons
PDLIAS	Provide information to own department via liaisons
POMEET	Provide information to other departments via group meetings
PDMEET	Provide information to own department via group meetings
ODLIAS	Obtain information from own department via liaisons
OOMEET	Obtain information from other departments via group meetings
OOLIAS	Obtain information from other departments via liaisons
ODMEET	Obtain information from own department via group meetings
FACTOR 2:	**Face-To-Face and Telephone Conversations**
OOTELCN	Obtain information from other departments via telephone conversations
OOFTF1	Obtain info. from other departments via one-on-one, face-to-face conversations
POTELCN	Provide information to other departments via telephone conversations
PDFTF1	Provide info. to own department via one-on-one, face-to-face conversations
ODFTF1	Obtain info. from own department via one-on-one, face-to-face conversations
PDTELCN	Provide information to own department via telephone conversations
POFTF1	Provide info. to other departments via one-on-one, face-to-face conversations
FACTOR 3:	**Written Formal Reports and Other Documents**
ODRPTS	Obtain information from own department via formal, written reports
PDRPTS	Provide information to own department via formal, written reports
ODWRIT	Obtain information from own department via other written documents
PORPTS	Provide information to other departments via formal, written reports
OORPTS	Obtain information from other departments via formal, written reports
FACTOR 4:	**Electronic Mail**
OOEMAIL	Obtain information from other departments via electronic mail
PDEMAIL	Provide information to own department via electronic mail
ODEMAIL	Obtain information from own department via electronic mail
POEMAIL	Provide information to other departments via electronic mail
FACTOR 5:	**Voice Mail**
PDVMAIL	Provide information to own department via voice mail
POVMAIL	Provide information to other departments via voice mail

Daft, 1989; Zmud, Lind, & Young, 1990). Consistent with the findings of these studies, the factor analysis of media for this dissertation indicated that factors were extracted according to media types previously shown in Table 5–20. The first scale, using paper media, is based on the four items that loaded on the third factor that consisted of use of written formal reports and documents, and this is termed the first lean scale (LEAN1). The second scale, using CMC media, is based on the four electronic mail items that loaded on the fourth factor, and this is termed the second lean scale (LEAN2).

The effectiveness scale, consisting of the unweighted sum of the eight, five-point, Likert scale items in the survey of items a–h in question 22, was examined with both PC factor analysis and scale alpha to assess the reliability. The alpha coefficient, as reported earlier in Table 5–2 was .82, and the factor analysis loaded on a single factor, so the solution could not be rotated. Results of the factor analysis for the effectiveness scale are given in Table 5–22, and it indicates that all items in the scale loaded on the single factor at .60 or higher.

As explained in the previous part, the method to carry out the hypothesis-testing procedure consisted of an ANCOVA technique in a three-variable case involving one nominal variable (low vs. high analyzability) and two interval scales (frequency of media use and degrees of effectiveness). The dependent (criterion) variable was effectiveness. The independent variable was media use.

The low vs. high analyzability nominal scale represents the interval analyzability scale that has been categorized by using the lower and upper quartile range limits. The ANCOVA procedure relates the differences

Table 5–22

FACTOR ANALYSIS

Effectiveness

FINAL STATISTICS:

VARIABLE	COMMUNALITY	*	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
		*				
EFFECT1	.38	*	1	3.50	43.8	43.8
EFFECT2	.54	*				
EFFECT3	.36	*				
EFFECT4	.38	*				
EFFECT5	.46	*				
EFFECT6	.53	*				
EFFECT7	.41	*				
EFFECT8	.45	*				

VARIMAX ROTATION 1 FOR EXTRACTION 1 IN ANALYSIS 1 - KAISER NORMALIZATION.

FACTOR MATRIX:

>Warning # 11310

>Only one factor was extracted. The solution cannot be rotated.

	FACTOR 1
EFFECT2	.74
EFFECT6	.73
EFFECT5	.68
EFFECT8	.67
EFFECT7	.64
EFFECT4	.62
EFFECT1	.61
EFFECT3	.60

between effectiveness and media use within categories of the analyzability control variable.

As explained in Part 4, to test the significance of the difference between the two categorized groups, the statistic for such a comparison is given by Kleinbaum and Kupper (1978) in the general form of a ratio with the difference in sample values of the correlations in the numerator and the square root of the sum of the variances in the denominator:

$$Z' = \frac{\frac{1}{2}\log_e\left(\frac{1+r_1}{1-r_1}\right) - \frac{1}{2}\log_e\left(\frac{1+r_2}{1-r_2}\right)}{\sqrt{\frac{1}{N_1-3}+\frac{1}{N_2-3}}} \tag{5.1}$$

The Z' equation converts the correlations to their respective Z' values, and the difference between the two is divided by the square root of the sum of the variances. The absolute value of the result is evaluated by a table of Z' values, and for a two-tailed test at the $p \leq .01$ level must exceed the critical value of 2.58 to reject the null hypothesis that the coefficients for the groups are the same. Results of this computation are summarized in Table 5–23.

For the paper media and effectiveness data in the low analyzability environment, the correlation coefficient was computed as $r_1 = .2613$ ($N = 332$), and for the paper media and effectiveness data in the high analyzability environment, the correlation was $r_2 = .2299$ ($N = 254$). Substituting these values into the above equation to convert the correlations and compute the test of significance on the difference of the Z' values, we obtain a result of .401. This fails to exceed the critical value of 2.58, so it is concluded that there is no significant difference between correlations of effectiveness and use of paper media in task environments stratified by analyzability.

Table 5–23

Z′ TRANSFORMATION

Computation Summaries for H. 7

	LOW ANALYZABILITY	HIGH ANALYZABILITY
PAPER MEDIA (LEAN1) $N = 586$	EFFECTIVENESS r .2613 $N = 332$	EFFECTIVENESS r .2299 $N = 254$
CMC MEDIA (LEAN2) $N = 579$	EFFECTIVENESS r .0263 $N = 325$	EFFECTIVENESS r .0593 $N = 254$

Paper Media and Effectiveness:

$$Z' = \frac{\frac{1}{2}\log_e\left(\frac{1+.2613}{1-.2613}\right) - \frac{1}{2}\log_e\left(\frac{1+.2299}{1-.2299}\right)}{\sqrt{\frac{1}{332-3} + \frac{1}{254-3}}}$$

$$= \frac{\frac{1}{2}\log_e(1.7075) - \frac{1}{2}\log_e(1.597)}{\sqrt{\frac{1}{329} + \frac{1}{251}}}$$

$$= \frac{.2675 - .2340}{\sqrt{.0030 + .00398}}$$

$$= \frac{.0335}{\sqrt{.00698}}$$

$$= .401$$

Table continued on following page

Table 5–23, Continued

Z′ TRANSFORMATION

Computation Summaries for H. 7

CMC Media and Effectiveness:

$$Z' = \frac{\frac{1}{2}\log_e\left(\frac{1+.0263}{1-.0263}\right) - \frac{1}{2}\log_e\left(\frac{1+.0593}{1-.0593}\right)}{\sqrt{\frac{1}{325-3}+\frac{1}{254-3}}}$$

$$= \frac{\frac{1}{2}\log_e(1.054) - \frac{1}{2}\log_e(1.126)}{\sqrt{\frac{1}{322}+\frac{1}{251}}}$$

$$= \frac{.02629 - .05937}{\sqrt{.00310+.00398}}$$

$$= \frac{-.03308}{\sqrt{.00780}}$$

$$= -.375$$

CONCLUSION: Neither Paper Media nor CMC Media Exceed Critical Values

H. 7 Not Supported; Null Hypothesis Not Rejected

Likewise, for CMC media and effectiveness data, the low analyzability correlation coefficient was computed as $r_1 = .0263$ ($N = 325$), and for the CMC–effectiveness data in the high analyzability environment, the correlation was computed as $r_2 = .0593$ ($N = 254$). By substituting these values into equation 5.1, converting the correlations, and computing the test of significance on the difference of the Z' values, we obtain a final statistic of -.375. Because this value fails to exceed the critical value of 2.58, it is again concluded that there is no significant difference between correlations of effectiveness and use of CMC media in task environments stratified by analyzability.

The results of the analysis indicate that correlations between effectiveness and the use of paper documents and CMC media are not significantly different between the two analyzability groups; therefore, the null hypothesis cannot be rejected, and we conclude the hypothesized relation is not significant. Regression plots of the slopes are given in Figures 5–14 and 5–15.

RESULT: H. 7 is not supported.

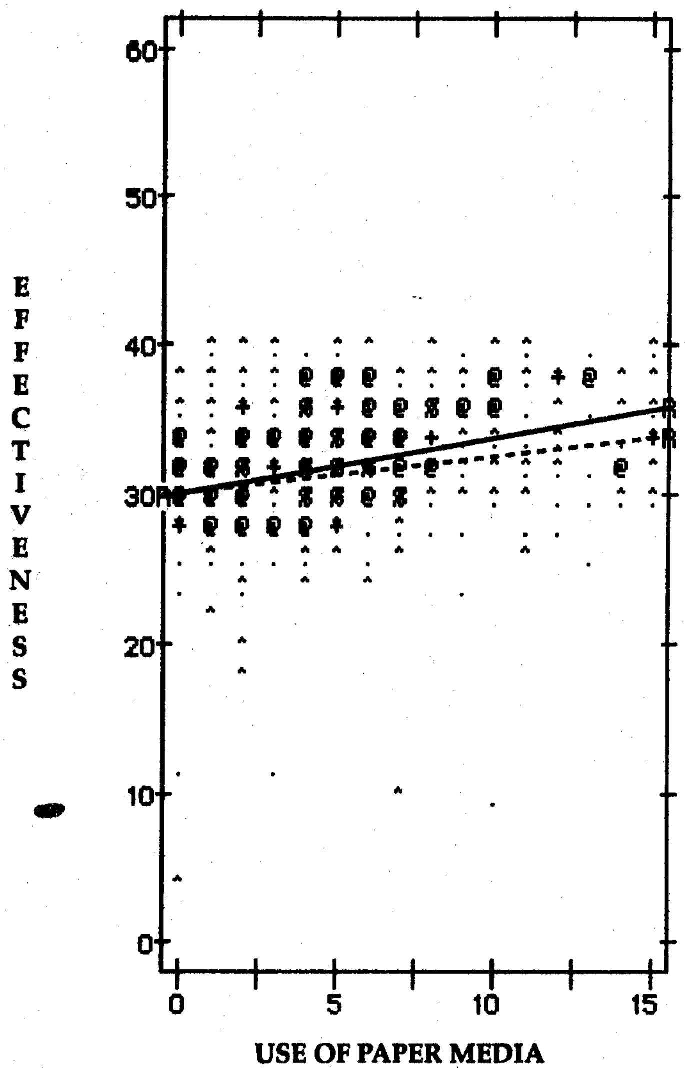
5.2.8 Hypothesis 8

H. 8: Use of information-lean media will be less strongly associated with positive effectiveness measures in equivocal environments.

As stated in the previous chapter, this test further examines hypothesized relations among media use, overall effectiveness, and environmental influence, and the analysis is similar to the one given above.

Figure 5–14

Regression Plots of Effectiveness Slopes and Use of Paper Media in Environments Stratified by Analyzability (H. 7)

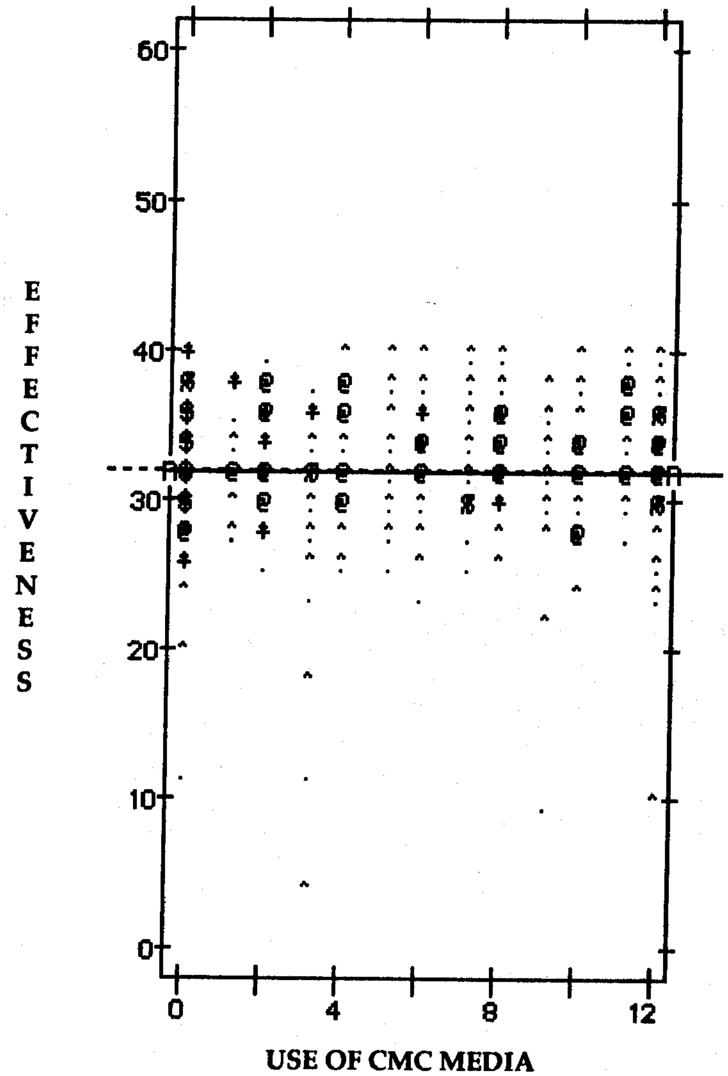


Low Analyzability ———— **Cases:** ^ 3
@ 6
% 9
$ 12

High Analyzability — — — **Cases:** . 3
+ 6
* 9
~ 12

Figure 5–15

Regression Plots of Effectiveness Slopes and Use of CMC Media in Environments Stratified by Analyzability (H. 7)



Low Analyzability	———	**Cases:** ^	3
		@	6
		%	9
		$	12
High Analyzability	— — —	**Cases:** .	3
		+	6
		*	9
		~	12

For the categorical variables, the stratification of groups is by equivocality rather than analyzability.

The categorical scale of low vs. high overall equivocality was obtained by using a combination of the H. 6 equivocality scales' lower and upper quartile range limits for task and inter-unit equivocality. The same media and effectiveness scales used in H. 7 were used here, and the method similarly compares the findings to a Z ' table to reject or not reject the null hypothesis. Results of these computations are summarized in Table 5–24.

The calculation yielded a value of -1.62 which fails to exceed the critical value of 2.58, so it is concluded that there is no significant difference between correlations of effectiveness and use of paper media in task environments stratified by equivocality.

In the second part of the analysis, the computation of the test statistic yielded a value of -1.20. Again, this number does not exceed the critical value of 2.58 to reject the null hypothesis, so it is concluded, as in the previous case, that correlations between effectiveness and use of CMC media in task environments stratified by equivocality are not significantly different.

The results of the analysis indicate that correlations between effectiveness and the use of either written documents or CMC are not significantly different between the two equivocality groups. Regression plots of the slopes for paper media are given in Figure 5–16, and plots of the slopes for CMC media are illustrated in Figure 5–17.

RESULT: H. 8 is not supported.

Table 5–24

Z' TRANSFORMATION

Computation Summaries for H. 8

	LOW EQUIVOCALITY	HIGH EQUIVOCALITY
PAPER MEDIA (LEAN1) $N = 615$	EFFECTIVENESS r .1232 $N = 322$	EFFECTIVENESS r .2489 $N = 293$
CMC MEDIA (LEAN2) $N = 607$	EFFECTIVENESS r -.0095 $N = 318$	EFFECTIVENESS r .0887 $N = 289$

Paper Media and Effectiveness:

$$Z' = \frac{\frac{1}{2}\log_e\left(\frac{1+.1232}{1-.1232}\right) - \frac{1}{2}\log_e\left(\frac{1+.2489}{1-.2489}\right)}{\sqrt{\frac{1}{322-3}+\frac{1}{293-3}}}$$

$$= \frac{\frac{1}{2}\log_e(1.281) - \frac{1}{2}\log_e(1.6628)}{\sqrt{\frac{1}{319}+\frac{1}{290}}}$$

$$= \frac{.1238-.2542}{\sqrt{.0031+.0034}}$$

$$= \frac{-0.1304}{\sqrt{.0065}}$$

$$= -1.62$$

Table continued on following page

Table 5–24, Continued

Z′ TRANSFORMATION

Computation Summaries for H. 8

CMC Media and Effectiveness:

$$Z' = \frac{\frac{1}{2}\log_e\left(\frac{1+(-0.0095)}{1-(-0.0095)}\right) - \frac{1}{2}\log_e\left(\frac{1+.0887}{1-.0887}\right)}{\sqrt{\frac{1}{318-3}+\frac{1}{289-3}}}$$

$$= \frac{\frac{1}{2}\log_e(.9812) - \frac{1}{2}\log_e(1.1947)}{\sqrt{\frac{1}{315}+\frac{1}{286}}}$$

$$= \frac{-0.0095-.0889}{\sqrt{.0032+.0035}}$$

$$= \frac{-0.0984}{\sqrt{.0067}}$$

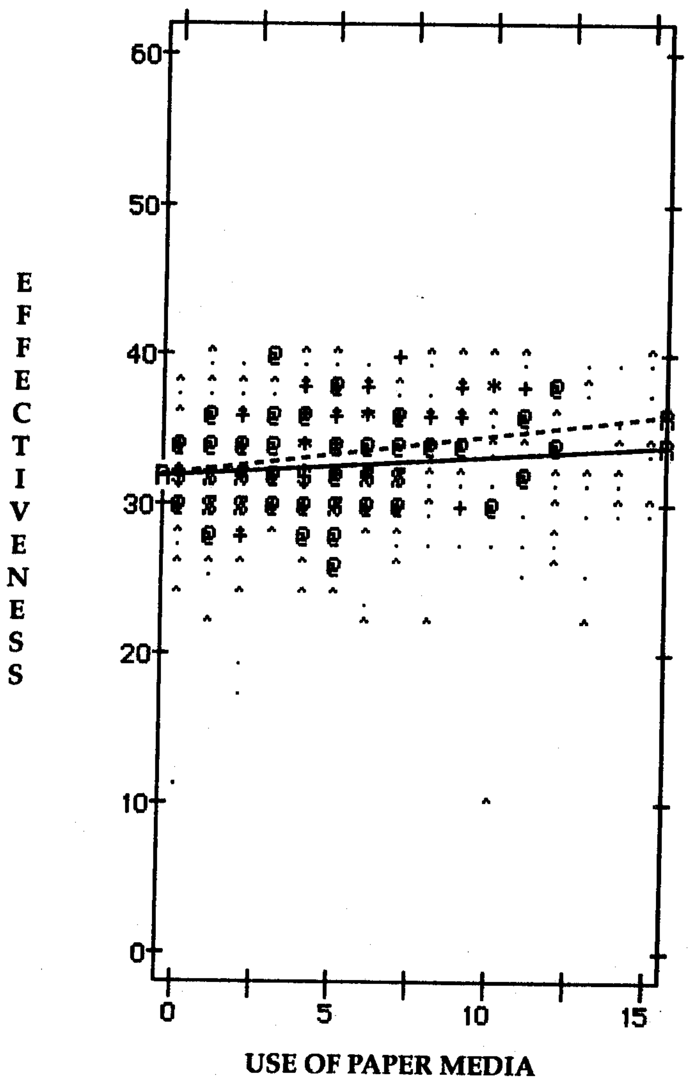
$$= -1.20$$

CONCLUSION: Neither Paper Media nor CMC Media Exceed Critical Values

H. 8 Not Supported; Null Hypothesis Not Rejected

Figure 5–16

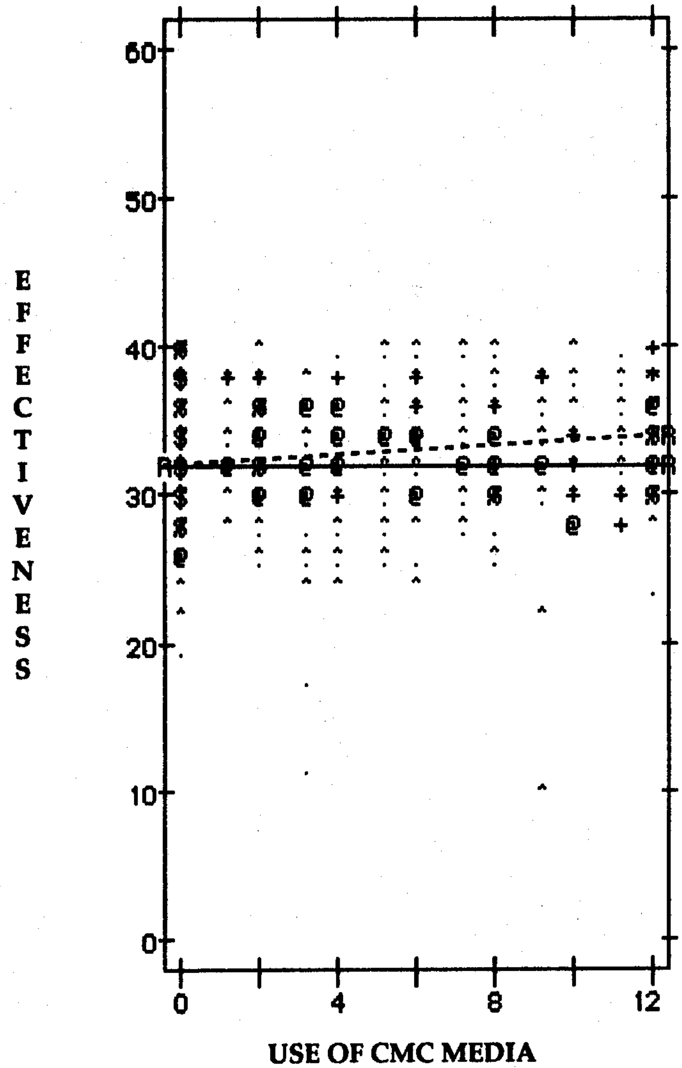
Regression Plots of Effectiveness Slopes and Use of Paper Media in Environments Stratified by Equivocality (H. 8)



Low Equivocality	————	**Cases:** ^	3
		@	6
		%	9
		$	12
High Equivocality	— — —	**Cases:** .	3
		+	6
		*	9
		~	12

Figure 5–17

Regression Plots of Effectiveness Slopes and Use of CMC Media in Environments Stratified by Equivocality (H. 8)



Low Equivocality	————	**Cases:** ^	3
		@	6
		%	9
		$	12
High Equivocality	— — —	**Cases:** .	3
		+	6
		*	9
		~	12

5.2.9 Hypothesis 9

H. 9: Effectiveness is positively related to media use when the medium is matched to task characteristics.

In this analysis, when groups are stratified by analyzability, the hypothesis tests investigated whether use of rich media correlated more highly with effectiveness in the low analyzability group than in the high analyzability group. In other words, the hypothesis tests are the same as those undertaken in H. 7, with the exception that in this analysis the significance tests on the differences of the Z' transformations extend to the correlations between effectiveness and use of rich media rather than lean media.

The rich media scales were developed using the same procedures as were used to develop the scales for lean media. As previously stated, the items on media use from questions 12 a–h, 13 a–h, 14 a–h, 15 a–h were tested for sampling adequacy, yielding a robust KMO index of .85 (Kaiser, 1974). The (PC) factor analysis extracted three principal components for rich media. The factor loadings were given in Table 5–20 and indicated that factor one includes group meetings and use of liaisons; factor two includes face-to-face and telephone conversations, and factor five includes voice mail. The factors were identified by their corresponding variable names in Table 5–21.

The ANCOVA technique remains a three-variable case involving the categorical variable of low vs. high analyzability and the interval scales of frequency of media use and degrees of effectiveness where effectiveness is the dependent variable.

The significance test involved evaluating the correlations between effectiveness measures and use of rich media in groups stratified by low and

high quartile ranges of analyzability. The significance tests on the differences of the Z ' transformations of the correlations again must exceed the critical value of 2.58 to reject the null hypothesis that the correlation coefficients for the two groups are the same. Results of these computations are summarized in Table 5–25.

The computation yielded a value of -0.43. It fails to exceed the critical value of 2.58, so we conclude that there is no significant difference between correlations of effectiveness and use of group meetings and liaisons in task environments stratified by analyzability. Also, the regression plots illustrated in Figure 5–18 show nearly identical overlapping of the effectiveness slopes which corroborates the finding that the groups are not significantly different.

The conversion of the correlations for effectiveness with face-to-face and telephone conversations in the stratified environments and the computations of the significance test of the groups gives a final value of .257 which fails to exceed the critical value of 2.58. In this analysis as well, we conclude that there is no significant difference between correlations of effectiveness and use of face-to-face and telephone conversations in the stratified task environments. The regression plots illustrated in Figure 5–19 similarly indicate a nearly identical overlap of the slopes.

Conversion of the correlations for telephone voice mail in the two environments grouped by low and high analyzability and the final significance test statistic of -0.337 fails to exceed the critical value of 2.58. We again conclude that there is no significant difference between correlations of effectiveness and use of voice mail in task environments stratified by

Table 5–25

Z′ TRANSFORMATION

Computation Summaries for H. 9

	LOW ANALYZABILITY	HIGH ANALYZABILITY
GROUP MEETINGS & USING LIAISONS (RICH1) $N = 586$	EFFECTIVENESS r .1599 $N = 332$	EFFECTIVENESS r .1635 $N = 254$
FACE-TO-FACE & PHONE CONVERSATIONS (RICH2) $N = 588$	EFFECTIVENESS r .1134 $N = 333$	EFFECTIVENESS r .0920 $N = 255$
USE OF VOICE MAIL MEDIA (RICH3) $N = 564$	EFFECTIVENESS r -.0270 $N = 321$	EFFECTIVENESS r .0556 $N = 243$

Meetings & Liaisons and Effectiveness:

$$Z' = \frac{\frac{1}{2}\log_e\left(\frac{1+.1599}{1-.1599}\right) - \frac{1}{2}\log_e\left(\frac{1+.1635}{1-.1635}\right)}{\sqrt{\frac{1}{332-3} + \frac{1}{254-3}}}$$

$$= \frac{\frac{1}{2}\log_e(1.381) - \frac{1}{2}\log_e(1.391)}{\sqrt{\frac{1}{329} + \frac{1}{251}}}$$

$$= \frac{.1614 - .1650}{\sqrt{.0030 + .0040}}$$

$$= \frac{-0.0036}{\sqrt{.007}}$$

$$= -0.43$$

Table continued on following page

Table 5–25, Continued

Z' TRANSFORMATION

Computation Summaries for H. 9

Face-to-Face & Phone and Effectiveness:

$$Z' = \frac{\frac{1}{2}\log_e\left(\frac{1+.1134}{1-.1134}\right) - \frac{1}{2}\log_e\left(\frac{1+.0920}{1-.0920}\right)}{\sqrt{\frac{1}{333-3} + \frac{1}{255-3}}}$$

$$= \frac{\frac{1}{2}\log_e(1.256) - \frac{1}{2}\log_e(1.203)}{\sqrt{\frac{1}{330} + \frac{1}{252}}}$$

$$= \frac{.1140 - .0924}{\sqrt{.0030 + .0040}}$$

$$= \frac{.0216}{\sqrt{.007}}$$

$$= .257$$

Table continued on following page

Table 5–25, Continued

Z′ TRANSFORMATION

Computation Summaries for H. 9

Voice Mail and Effectiveness:

$$Z' = \frac{\frac{1}{2}\log_e\left(\frac{1+(-0.0270)}{1-(-0.0270)}\right) - \frac{1}{2}\log_e\left(\frac{1+.0556}{1-.0556}\right)}{\sqrt{\frac{1}{321-3}+\frac{1}{243-3}}}$$

$$= \frac{\frac{1}{2}\log_e(1.055) - \frac{1}{2}\log_e(1.1177)}{\sqrt{\frac{1}{318}+\frac{1}{240}}}$$

$$= \frac{.0268-.0556}{\sqrt{.0031+.0042}}$$

$$= \frac{-0.0288}{\sqrt{.0073}}$$

$$= -0.337$$

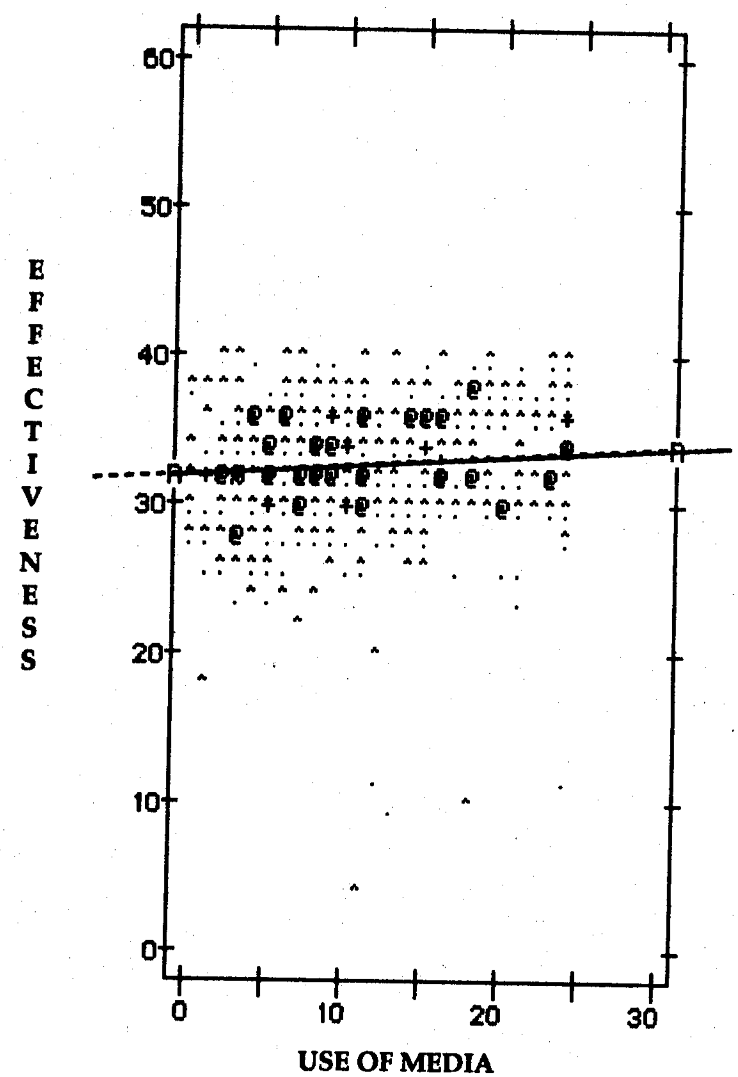
CONCLUSION: No Media Variables Exceed Critical Values

H. 9 Not Supported; Null Hypothesis Not Rejected

Figure 5–18

Regression Plots of Effectiveness Slopes and
Use of Rich Media in Environments Stratified by Analyzability (H. 9)

Group Meetings and Use of Liaisons - RICH1



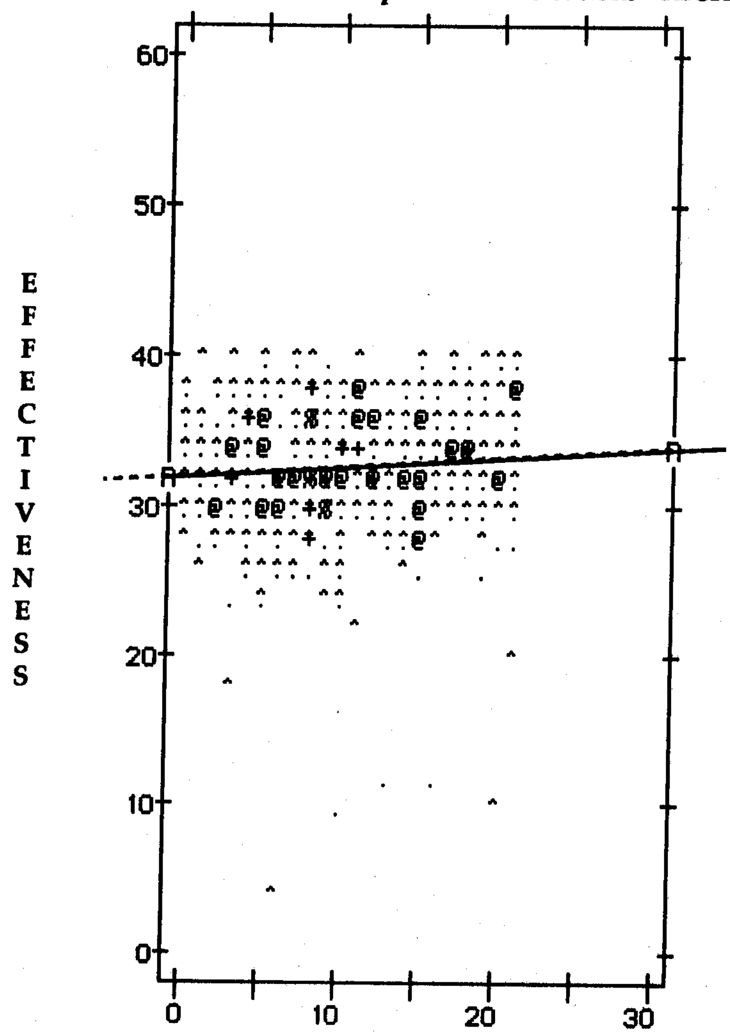
Low Analyzability ——— Cases: ^ 3
@ 6
% 9
$ 12

High Analyzability — — — Cases: . 3
+ 6
* 9
~ 12

Figure 5–19

Regression Plots of Effectiveness Slopes and Use of Rich Media in Environments Stratified by Analyzability (H. 9)

Face-To-Face and Telephone Conversations - RICH2



Low Analyzability ———— Cases: ^ 3
@ 6
% 9
$ 12

High Analyzability — — — Cases: . 3
+ 6
* 9
~ 12

analyzability. The effectiveness slopes show nearly the same overlap in Figure 5–20 as do those in the previous two figures.

The results of the analysis indicate that correlations between effectiveness and the specified media variables are not significantly different between the two analyzability groups; therefore the null hypothesis cannot be rejected, and we conclude on the basis of both the tests of significance and the nearly identical regression lines plotted between groups that the hypothesized relations are not significant.

RESULT: H. 9 is not supported.

5.2.10 Hypothesis 10

H. 10: Effectiveness is negatively related to media use when the medium is not matched to task characteristics.

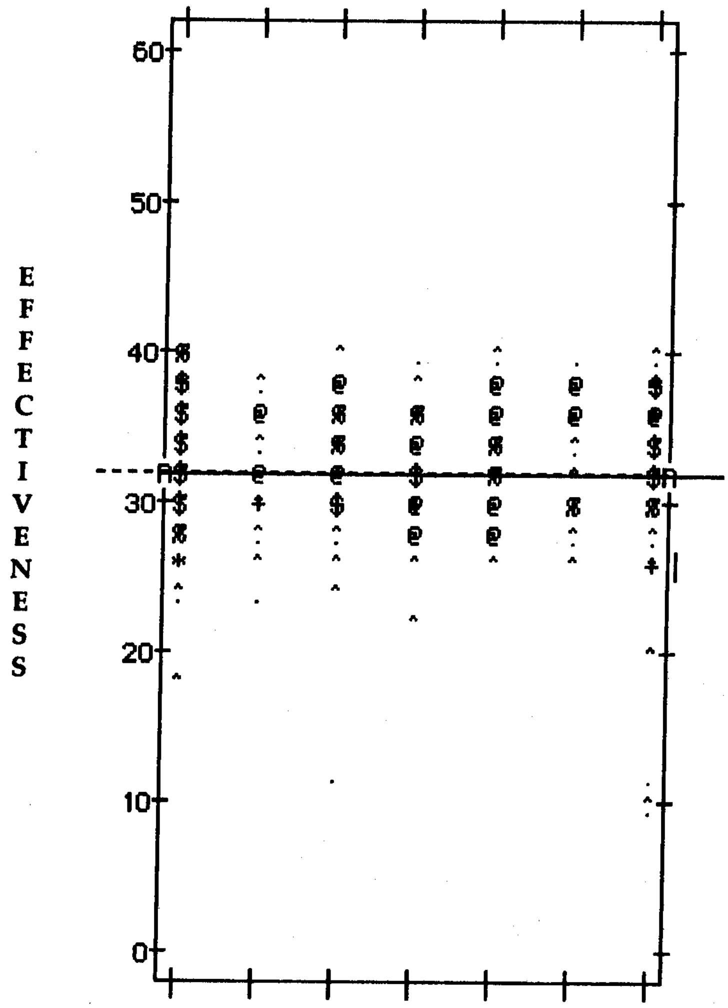
This analysis intended to examine the reverse side of the previous hypothesis test. That is, when groups were stratified by analyzability (as done previously), it was to test the hypothesis that use of rich media would have a lower correlation with effectiveness in the high analyzability group than in the low analyzability group. It was to use the same media scales, and the significance test involved evaluating the correlations between effectiveness measures and use of rich media between groups stratified by analyzability. The significance tests on the differences of the Z ' transformations of the correlations had to exceed the critical value of 2.58 to reject the null hypothesis.

Results of the computations to test H. 9, however, have caused the analysis of H. 10 to have no practical importance. The H. 9 computations and

Figure 5–20

Regression Plots of Effectiveness Slopes and Use of Rich Media in Environments Stratified by Analyzability (H. 9)

Telephone Voice Mail - RICH3



USE OF MEDIA

Low Analyzability	————	Cases: ^	3
		@	6
		%	9
		$	12
High Analyzability	— — —	Cases: .	3
		+	6
		*	9
		~	12

plots of the regression lines have already indicated that the media use in the stratified groups is nearly the same. Therefore, the null hypothesis cannot be rejected, and we conclude that the proposed relation is not significant.

RESULT: H. 10 is not supported.

5.2.11 Summary of Hypothesis Tests

As explained at the start of this chapter, three hypotheses (H. 2, H. 3, and H. 5) were supported with statistical significance. H. 1 had statistical significance, but in the opposite direction from what was predicted. The remaining hypotheses were not supported. A summary table of all ten hypotheses and their results is given in Table 5–26. Part 6, Discussion and Conclusion, discusses the findings with respect to theory and offers post hoc analysis of what the data show.

5.3 Triangulation

Two methods have been used to triangulate the findings in the quantitative survey. The first, a telephone survey of randomly chosen subjects who were part of the original subject pool, has yielded the fewest insights into the data. Overall, the subjects seemed unwilling to be interviewed on a phone line, and of an original list of 50 possible subjects whose names could be found in phone directories, five (10%) agreed to be interviewed. Consequently, the researcher sought to broaden the scope of the triangulation by extending the qualitative data collection to the form of a face-to-face discussion involving twenty-seven AIAA members. The meeting took place at the Knowledge Diffusion Research Project session of the 32nd

Table 5–26

SUMMARY OF HYPOTHESES TESTS

H. 1:	The greater the degree of task variety, the greater the amount of perceived uncertainty. Not supported. (Significance of $p \leq .01$ in opposite direction.)
H. 2:	The greater the degree of task analyzability, the less the amount of perceived uncertainty. Supported. (Significance of $p \leq .0001$.)
H. 3:	The greater the amount of uncertainty, the greater the use of CMC. Supported. (Significance of $p \leq .001$.)
H. 4:	The higher the level of uncertainty, the more CMC use will extend to persons outside of the organization. Not supported.
H. 5:	The greater the degree of analyzability, the greater the use of CMC. Supported. (Significance of $p \leq .01$.)

Table continued on the following page

Table 5–26, Continued

SUMMARY OF HYPOTHESIS TESTS

H. 6:	The greater the amount of perceived equivocality, the less the use of CMC. Not supported.
H. 7:	Use of information-lean media will be more strongly associated with positive effectiveness measures in analyzable environments. Not supported.
H. 8:	Use of information-lean media will be less strongly associated with positive effectiveness measures in equivocal environments. Not supported.
H. 9:	Effectiveness is positively related to media use when the medium is matched to task characteristics. Not supported.
H. 10:	Effectiveness is negatively related to media use when the medium is not matched to task characteristics. Not supported.

Annual AIAA Aerosciences Conference in Reno, Nevada, on January 11, 1994. The opinions of the participants in both the face-to-face session and the phone conversations are provided in the next section. The researcher's position is that the face-to-face session was the more effective of the two methods to obtain information to triangulate the original data.

5.3.1 Telephone Interview Results

Of the 50 subjects targeted for the phone triangulation, the researcher succeeded in conducting conversations with five individuals by the third try. The average conversation lasted twelve minutes. Below is a summary of the conversations with the AIAA members who agreed to participate.

All five subjects acknowledged receiving the survey. Two said that they had completed it and returned it. The other three said that they did not complete it because they did not use computers and felt that it was not applicable to their work. None of the interviewees reported that they had an unfavorable impression of the study. The two who did return it indicated that they felt surveys in general yield useful information. The three who had not completed it said that while they thought the survey could be useful, they felt it did not match their job descriptions and therefore declined to complete it.

Two subjects reported that they used computers at their jobs and said that as far as networks were concerned, they both were able to send and receive e-mail, and they both used FTP to obtain files. Three interviewees did not use computers at all. The three nonusers indicated that they were more or less "traditional" engineers, and they said that they did not feel that

they needed a computer to do their jobs. This sentiment is consistent with the findings of Kennedy, Pinelli, Hecht, and Barclay (1994) who describe aerospace engineers as individuals who build machines and "do engineering" in the sense that their goal is to create artifacts (things) rather than to create "facts" in the sense of developing or sharing new knowledge. That is, those respondents did not view using a computer or a computer network as tools necessary for them to have in order to carry out their engineering tasks. The two respondents who did use networks indicated that in addition to e-mail and file transfers, they used the computer for word processing and spreadsheets.

Overall, the nonusers were not inclined to discuss the use of networks. However, both of the computer users felt that they would use computer networks more if the people with whom they worked in their immediate environment used them. One of the subjects expressed a lively interest in expanding the use of computers in his functional area, but the individual also voiced some dismay at the prevailing atmosphere of nonuse among colleagues at work. The subject thought that using computers could simplify and expedite the work in that environment, but reported that this view was not shared by co-workers. One of the main reasons was that much of the work is only on paper, such as blueprints and technical drawings done by hand, so changing to computers would be difficult. One respondent said that the clerical staff in the office had more need to use a computer than did that individual as an engineer. The subject stated that in that area, there was no foreseeable shift toward using computers in the near (one or two year) future.

None of the respondents indicated that they were surprised by the finding that about a third of the respondents accounted for about 80% of the reported network use. The consensus was that computers are important for some people who tend to use them a lot. None of the interviewees asked any questions.

5.3.2 Meeting Interview Results

As previously mentioned, the author spoke face-to-face to a meeting of 27 AIAA members at a session on communication technology at the 32nd Annual AIAA Aerosciences Conference in Reno, Nevada. The researcher first presented to the assembly a summary of the purpose of the study and an explanation of the strategies employed to gather the data from the AIAA participants in the mail survey. The researcher outlined some of the main results, such as the finding that 30% of the subjects accounted for approximately 80% of the reported CMC use and the reported lack of computer network use to contact colleagues off-site. In a semi-directed discussion format, the researcher invited opinions from the audience with respect to these findings or on other aspects of the study.

Overall, the main barrier to computer network use that was vocalized by several AIAA members was the "fire-wall" mentality that is prevalent in the aerospace environment. This refers to a prevailing attitude, or in some cases strict policy measures, to prevent using networks in a workplace where sensitive data and research information is used on a regular basis. It implies that information must be safeguarded at all times, be shared only on a need to know basis, and suggests that computer networks are often perceived as

potential "holes" in the wall. One individual stated that the company spent "a lot" of money researching and developing information to build aircraft, and they did not want to risk giving information away through a computer network. The respondent said that after four or five years, research and development personnel at the company would publish the information in aerospace journals, but by that time it was no longer sensitive, and hence, no longer valuable in the competitive marketplace. This report is also consistent with the finding of Kennedy et al. (1994) that aerospace organizations will strive to become successful by having the "artifacts" they produce succeed in the marketplace by controlling the flows of scientific and technological information transfer.

A second theme concerning use of computers and networks centered on difficulties associated with training individuals and with finding time and resources to train personnel to use the newer technologies. Many participants said that it is now very difficult in these economic times—especially in the aerospace environment—to expect organizations to do large amounts of computer training for employees who do not have extensive computer skills. Coupled with this problem, one individual stated that 90% of the information used by most of their personnel exists only on paper; hence, it causes an attitudinal barrier on the part of many that until the information becomes either more available by using computers or is only available through using computers, that there will continue to be opposition to allocating resources to enhance computer access and training.

Lastly, the participants stated that there still seems to be a lack of standardization in the computer industry itself with respect to hardware and

software which causes some decision makers to adopt a "wait-and-see" attitude regarding purchasing decisions. This reticence to move to the use of computers causes day-to-day operations to continue in their present venue, which exacerbates the previous problem in that individuals are not gaining computer experience which will be necessary when and if the organizations do decide to embrace computer technology to help them perform their tasks. This finding is consistent with the research of Pinelli, Kennedy, and Barclay (1994) who reported that lack of computerized access is one of the inhibitors to effective and rapid dissemination of scientific and technical information among those who need to share it to be competitive in the marketplace.

5.3.3 Triangulation Summary

Overall, the data obtained in the telephone conversations did not provide much by way of new information, nor did it reveal valuable insights to the quantitative data. While respondents were cordial, the general impression the researcher received was that the subjects on the whole were reticent to be interviewed for unspecified reasons, so that conversations tended to be short, and information was not readily forthcoming. Of the information that was obtained, it was interesting to note that the individuals who did not use computers expressed no regret over not doing so and stated in varying language that they either they didn't need them at all or felt that other people will need to use them before they themselves will. This corroborated the finding in the survey that one out of four survey respondents do not use computers or networks, availability notwithstanding.

In contrast, the face-to-face meeting in Reno with the AIAA members helped to shed light on several findings of the survey that dealt with preferences for communication media not associated with networks: pockets of network avoidance in many cases may be tied to a "fire-wall" mentality that is designed to protect valuable information; some non-use may be tied to problems associated with training users in terms of time and money; there is a reticence on the part of some organizations to purchase computerized tools. A more detailed discussion of the overall study is provided in Part 6 of the dissertation, Discussion and Conclusion.

REFERENCES CITED IN PART 5

Babbie, E. R. (1979). The practice of social research (2nd ed.). Belmont, CA: Wadsworth.

Babbie, E. (1990). Survey research methods (2nd ed.). Belmont, CA: Wadsworth.

Balaguer, N. S. (1988). CIM information technology utilization and organizational design: A field study on information processing. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Bradley, J. (1972). Nonparametric statistics. In R. Kirk (Eds.), Statistical issues: A reader for the behavioral sciences (Sel. 9.1). Monterey, CA: Brooks/Cole.

Cattell, R. B. (Ed.). (1966). Handbook of multivariate experimental psychology. Chicago: Rand McNally.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. Management Science, 32, 554–571.

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection, and manager performance: Implications for information systems. Management Information Systems Quarterly, 11, 355–366.

Fulk, J., & Ryu, D. (1990). Perceiving electronic mail systems: A partial test of social information processing model of communication media in organizations. ICA, Dublin.

Glass, G., Peckham, P., & Sanders, J. (1972). Consequences of failure to meet assumptions underlying the fixed effects analysis of variance and covariance. Review of Educational Research, 42, 237–288.

Kaiser, H. F. (1974). An index of factorial simplicity. Psychometrika, 39, 31–36.

Kennedy, J. M., Pinelli, T. E., Hecht, L. F., & Barclay, R. O. (1994). An analysis of the transfer of scientific and technical communications in aerospace. Annual Meeting of the American Sociological Association, Los Angeles.

Kerlinger, F. N. (1986). Foundations of behavioral research (3rd ed.). Fort Worth: Holt, Rinehart and Winston.

Kim, J., & Mueller, C. W. (1978). Introduction to factor analysis. Beverly Hills, CA: Sage.

Kleinbaum, D. G., & Kupper, L. L. (1978). Applied regression analysis and other multivariable methods. North Scituate, MA: Duxbury Press.

Lind, M. R., & Zmud, R. W. (1991). The influence of a convergence in understanding between technology providers and users on information technology innovativeness. Organization Science, 2(2), 195–217.

Norušis, M. J. (1990). SPSS Base system user's guide (4th ed.). Chicago: SPSS, Inc.

Nunnally, J. (1978). Psychometric theory (2nd ed.). New York: McGraw-Hill.

Pinelli, T. E., Kennedy, J. M., & Barclay, R. O. (1994). Information product use among aerospace engineers and scientists. (Report Number 21). NASA.

Rice, R. E. (1992). Task analyzability, use of new media, and effectiveness: A multi-site exploration of media richness. Organization Science, 3(4), 475–500.

Rummel, R. J. (1970). Applied factor analysis. Evanston, IL: Northwestern University Press.

Schmitz, J., & Fulk, J. (1990). The role of organizational colleagues in media selection. ICA, Dublin.

Schmitz, J., & Fulk, J. (1991). Organizational colleagues, media richness, and electronic mail: A test of the social influence model of technology use. Communication Research, 18(4), 487-523.

Short, J., Williams, E., & Christie, B. (1976). The social psychology of telecommunications. London: Wiley.

Trevino, L. K., Daft, R. L., & Lengel, R. H. (1990). Understanding managers' media choices: A symbolic interactionist perspective. In J. Fulk & C. Steinfield (Eds.), Organizations and communication technology (pp. 71–94). Newbury Park, CA: Sage.

Trevino, L. K., Lengel, R., & Bodensteiner, W. (1990). The richness imperative and cognitive style: The role of individual differences in media choice behavior. Management Communication Quarterly, 4(2), 176–197.

Triscari, T. (1984). Organizations and information processing: A field study of research and development units within the United States Air Force systems command. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Tyler, B. B., Bettenhausen, K. L., & Daft, R. L. (1989). The use of low and high rich information sources and communication channels in developing and implementing competitive business strategy. In Academy of Management Proceedings (pp. 245–249).

Young, R. K., & Veldman, D. J. (1981). Introductory statistics for the behavioral sciences (4th ed.). New York: Holt, Rinehart and Winston.

Zmud, R., Lind, M., & Young, F. (1990). An attribute space for organizational communication channels. Information Systems Research, 1(4), 440–457.

PART 6

DISCUSSION AND CONCLUSION

6.1 Introduction

This research into scientific and technical information (STI) transfer was grounded on a framework that conceptualized the complex aerospace enterprises that produce and share STI as information-processing (IP) systems. Beneath this model is the proposition that individuals process information using various media to reduce uncertainty and equivocality associated with their tasks. The model further suggests that certain contextual (task environment) variables affect the requirements of the individuals who process information, and it proposed that effectiveness could be increased by fitting the individuals' IP requirements with the proper match of IP capabilities (Tushman & Nadler, 1978). Derived from IP theory and based in part on previous research (Triscari, 1984), this project examined information processing with respect to STI and theory using the following methods:

1) operationalizing the IP model using variables and measures from previous research as presented in Part 2;
2) using field-study research methods to test relationships hypothesized to exist among variables specified in the model;
3) analyzing the results of the hypothesis tests to examine consistency of the findings between the variables in the IP model and the empirical evidence;
4) offering viewpoints and drawing conclusions based on the empirical data.

6.2 Review of the Results

As explained in Part 4, analysis was based on individual responses averaged across participants. Using a systematic random sampling of members of the AIAA, a total of 1006 respondents who volunteered to participate in the study were included in the analysis. Table 6–1 shows the subjects divided according to their occupational duties and provides the percentages for each category. The three largest groups of subjects (Design and Development, Administration and Management, Research) taken together comprise 720 individuals, approximately 70% of the sample. The remaining 30% of the subjects work in areas related to aerospace development.

All of the scales used in the study for hypothesis tests were based upon scales that were used in previous studies as described in Part 4, summarized in Table 4–1, and confirmed using principal-components (PC) factor analysis. Of the ten hypotheses proposed, three hypotheses (H. 2, H.3, and H. 5) that involved measures of either uncertainty or analyzability and corresponding CMC use were supported with the statistical significance at $p \leq .01$ or better. Hypothesis H. 1 involving variety and uncertainty was significant at $p \leq .01$, but opposite to the predicted direction. The remaining hypotheses were not supported. Discussion of the results for the hypothesis tests is provided below.

6.3 Hypothesis 1: Significant in the Opposite Direction

H. 1: The greater the degree of task variety, the greater the amount of perceived uncertainty.

Table 6–1

SURVEY RESPONSE STATISTICS

Subjects' Present Professional Duties

Duties

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Research	1	175	17.4	17.6	17.6
Teaching/Academic	2	55	5.5	5.5	23.1
Administration/ Management	3	231	23.0	23.2	46.3
Design/ Development	4	314	31.2	31.5	77.8
Manufacturing/ Production	5	18	1.8	1.8	79.6
Service/ Maintenance	6	22	2.2	2.2	81.8
Marketing/Sales	7	54	5.4	5.4	87.2
Private Consultant	8	34	3.4	3.4	90.7
Other	9	93	9.2	9.3	100.0
	99	10	1.0	Missing	
	Total	1006	100.0	100.0	

This hypothesis was concerned with the contextual variables of variety and uncertainty as they are associated with the aerospace task environment. The factor loadings of the scales for variety and uncertainty as given in Table 5–7's covariance matrix appear robust at .68 and .70 respectively. Contrary to the researcher's expectations, the data revealed a significant ($p \leq .01$) but slight inverse relationship between the variables, opposite to what was expected. Essentially, the data show that increased levels of task variety do not yield increased levels of uncertainty as the model predicts. It is difficult to account for this modest finding as it does not comport with our understanding of the relation between these two variables as discussed in the IP literature.

Post hoc analysis is speculative, but a possible explanation of the inverse relation between variety and uncertainty could be offered in terms of the high educational levels of the AIAA subjects and the likelihood of consequent high self-confidence. Frequency distributions of the academic preparation data obtained from the demographic portion of the survey indicate in Table 6–2 that 947 of the subjects (95%) were trained either as engineers or scientists and that 683 of the subjects (68%) earned masters degrees or higher. These high levels of academic achievement are generalizable to the target population, as prior research indicates that almost 30% of the total AIAA membership hold doctorates (Pinelli, 1991). It is therefore conceivable that considerable academic preparation in problem-solving methodologies has yielded a population of individuals who possess very high levels of confidence in their abilities to cope with problems in general. This is perhaps borne out of their engineering or scientific training which emphasizes applying analytical, problem-solving methods to a variety

Table 6–2

SURVEY RESPONSE STATISTICS

Subjects' Educational Training

Academic Preparation

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Engineer	1	838	83.3	84.1	84.1
Scientist	2	109	10.8	10.9	95.0
Other	3	50	5.0	5.0	100.0
	9	9	.9	Missing	
	Total	1006	100.0	100.0	

Highest Academic Degree

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No degree	1	6	.6	.6	.6
Bachelors	2	292	29.0	29.3	29.9
Masters	3	438	43.5	44.0	74.0
Doctorate	4	198	19.7	19.9	93.9
Post-Doctorate	5	47	4.7	4.7	98.6
Other	6	14	1.4	1.4	100.0
	9	11	1.1	Missing	
	Total	1006	100.0	100.0	

of problems when they occur. If this were so, it is not unreasonable to expect that the mere variety of tasks alone is an insufficient condition to cause increased levels of uncertainty in this population. However, measures of self-confidence as influenced by education are not specified as variables in the IP literature to the best of the author's knowledge; therefore, they were not assessed in this study. Attributing self-confidence as an explanatory factor for the negative correlation between variety and uncertainty should therefore be interpreted with caution. It is recommended in Section 6.6 of this dissertation that future research seeking to test the hypothesized relationship between the variables of variety and uncertainty might consider obtaining data on levels of individuals' self-confidence, possibly correlated with levels of education and training, as additional antecedent variables to examine these relationships and possibly add more explanatory power to the model.

Additional information related to explaining this inverse relationship—again tied to academic training—was previously discussed by Triscari (1984) in his research into aerospace R&D units. He speculated that contextual variables in the task environments (e.g., analyzability) and communication patterns involving uncertainty could be consequences of the training that engineers undergo. That is, if it is feasible that engineers are encouraged and rewarded to solve problems out of their own resources or "know-how," then it is not unreasonable to expect that a high level of variety in the environments of trained engineers would not necessarily cause high levels of uncertainty. In other words, in such environments, variety might be viewed as somewhat of a work incentive or stimulus, or a source of diversion, or simply as an expected (i.e., "normal") dimension of the task

environment of engineers. But as previously cautioned, these relationships are not specified per se in the IP literature, were not tested empirically in this study, and should therefore be considered in the light of post hoc speculation as possible directions for future research.

The path diagram illustrated in Figure 6–1 provides the empirical results of the path coefficients between the variables. The coefficient between variety and uncertainty indicates a slightly negative (but significant) correlation, opposite to what was predicted in the first hypothesis, as previously discussed. (Readers will note that for path diagrams in Part 6, small rectangles indicate independent variables, and large rectangles indicate dependent variables. The *p* values are provided for those coefficients that are statistically significant.)

6.4 Hypotheses 2, 3, and 5: Significant in the Predicted Direction

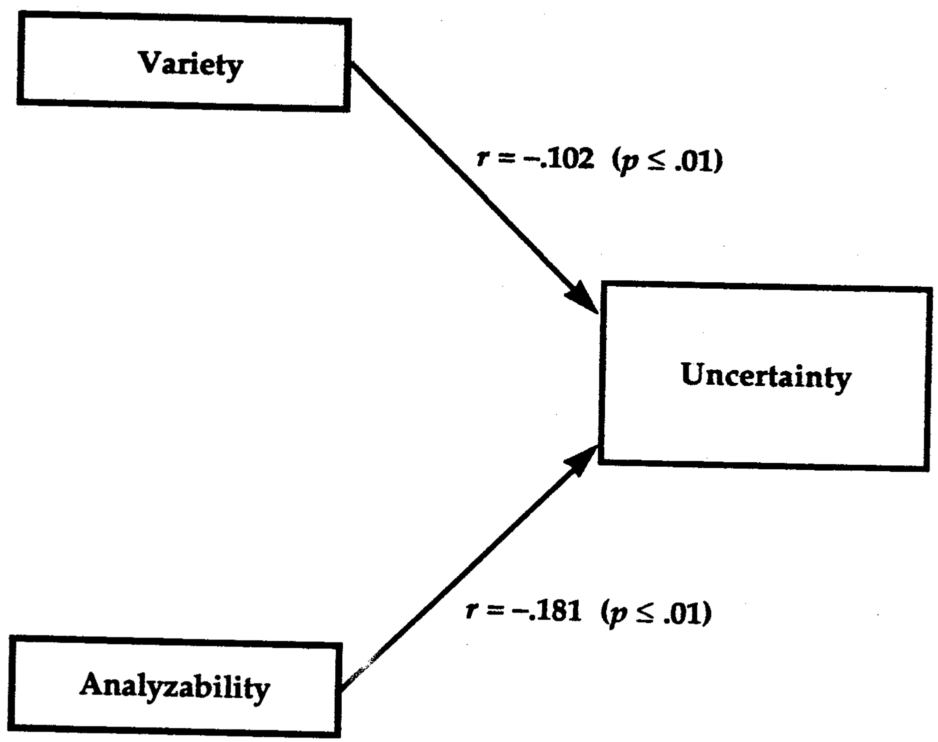
The hypothesis tests of H. 2, H. 3, and H. 5 were all concerned with contextual factors in the task environments, with the addition of CMC use as the dependent variable in H. 3 and H. 5. In all three tests, the findings were significant in the predicted directions, so the null hypotheses of no differences between groups were rejected, as the results are consistent with the predictions of the model.

The variables in H. 2, similar to those in H. 1 discussed above, also focused on contextual factors of the environment:

> H. 2: The greater the degree of task analyzability, the less the amount of perceived uncertainty.

Figure 6–1

Empirical Results of Path Relationships
Between Contextual IP Variables
(H. 1 and H. 2)



The hypothesis test confirmed at a strong $p \leq .0001$ level that as analyzability increases, uncertainty decreases. Locating the aerospace environment in Cell 4 (engineering technology) of the Daft and Lengel (1986) matrix illustrated in Figure 2–5 in Part 2 is consistent with the data and the model's proposition that a high capacity to provide procedural methods to solve difficulties (i.e., high analyzability) can reduce uncertainty by providing formal procedures to deal with problems when they do occur. The path coefficient for this hypothesis, previously given in Figure 6–1, indicates a slightly negative (but significant) correlation between analyzability and uncertainty as predicted by the model.

The second of the supported hypotheses, H. 3, also employed measurements of levels of uncertainty. It was the first of the hypothesis tests to extend the investigation to media use:

> H. 3: The greater the amount of uncertainty, the greater the use of CMC.

The IP model proposes that to resolve problems of uncertainty, obtaining answers to straightforward questions does not normally require extensive discussion; therefore, rich media are not needed to arrive at an answer. The model specifies that the more effective strategy would be to exchange specific information through a nonrich (or lean) medium, such as electronic mail. Consistent with the model's prediction, the hypothesis test of H. 3 confirmed that workers in high-uncertainty environments reported approximately one-fourth more job-related CMC use (12.0 hours per week versus 8.7 hours per week) than did the workers in low-uncertainty environments.

The path coefficient for H. 3 is illustrated in Figure 6–2, indicating a slight but significant correlation between uncertainty and overall CMC use as predicted by the model. (The path between uncertainty and CMC use extending beyond the organization is discussed in Section 6.5. which covers the hypotheses that were not supported by the data.)

Compatible with the positive correlation between uncertainty and CMC use confirmed by H. 3, the next analysis involved CMC as a medium to accommodate communication exchanges in analyzable environments as previously specified by Trevino, Lengel, and Bodensteiner (1990) and Rice (1992), whose research indicated only modest support for the contingent effect of task conditions affected by analyzability and use of new media:

> H. 5 The greater the degree of analyzability, the greater the use of CMC.

The test of H. 5 confirmed a statistically significant difference ($p \leq .01$) of differential amounts of CMC use between groups stratified by low and high analyzability. The path coefficient for H. 5 is provided in Figure 6–3.

Consistent with Galbraith's (1974) focus on relations between information processing variables and organizational dimensions such as uncertainty and analyzability, this research assessed subjects in terms of their information-sharing methods (Morgan, 1986; Simon, 1976). The implications of the findings of the three supported hypotheses tests examined above suggest that, on the whole, the contextual variables of uncertainty and analyzability appear to be modestly robust variables affecting the members' information requirements as specified by the IP model.

Figure 6–2

Empirical Results of Path Relationships Between Uncertainty and CMC Use (H. 3 and H. 4)

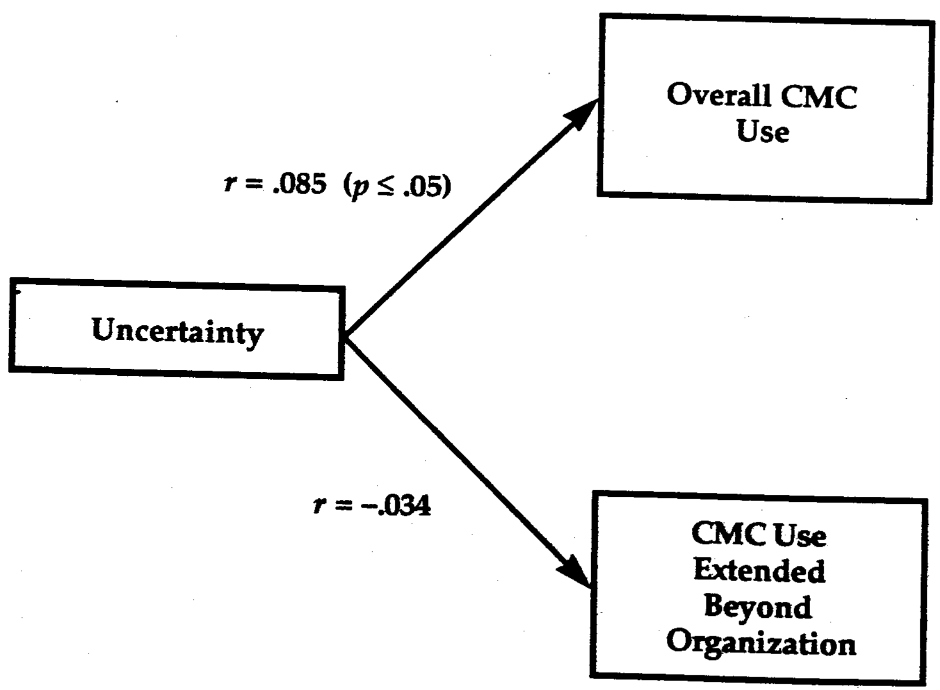
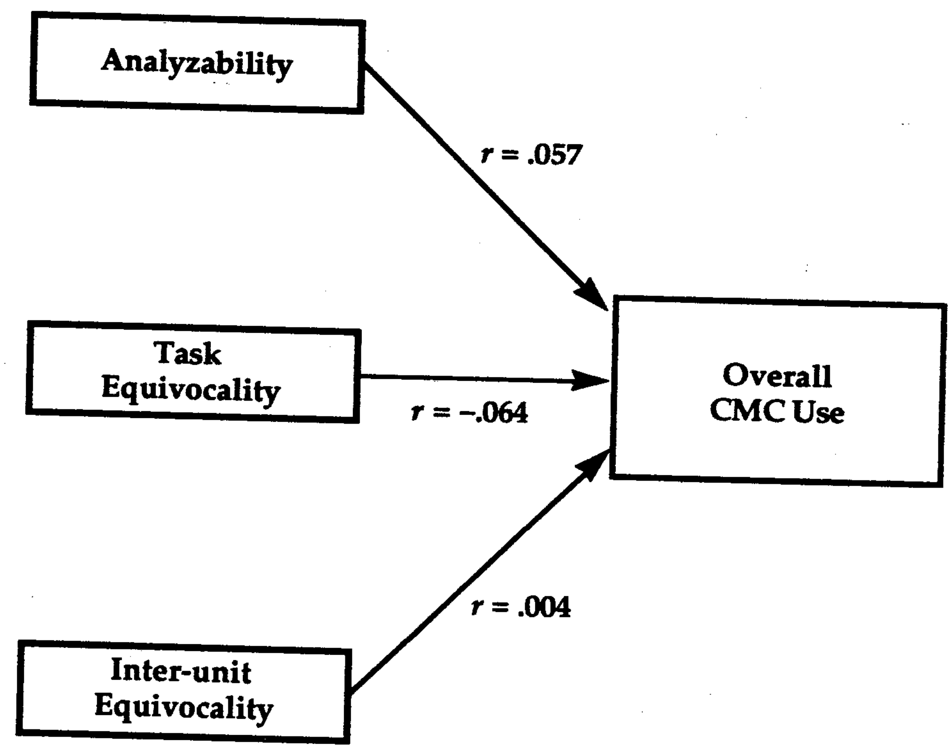


Figure 6–3

Empirical Results of Path Relationships Between Contextual IP Variables and CMC Use (H. 5 and H. 6)



6.5 Hypotheses 4, 6–10: Not Supported

The data do not provide empirical support for H. 4 which predicted more CMC use to persons outside of the organization in environments stratified by high levels of uncertainty. Responses obtained from the AIAA members in the Reno meeting for triangulation purposes offer a possible insight that may help explain these results. First, it should be noted that NASA is essentially a research and development enterprise, as are many of its aerospace affiliates and sub-contractors (Pinelli, Glassman, Oliu, & Barclay, 1989). As discussed in Part 5, there appears to be a prevailing attitude in aerospace communities that information is a commodity to be safeguarded from those who would seek to obtain it as a technological advantage over competitors. This is unlike much of the information generated through research conducted in academia where the expectation is to publish findings soon after they become available. So to a certain extent, CMC use in the aerospace environment may be perceived by some as a potential breach in the "fire wall" that keeps sensitive and expensive information in the hands of its researchers and developers. For future studies using this model, researchers may want to consider gathering data on a variable that could be assessed with respect to differentiated levels of information "propriety" as a contextual factor that, in the environment of the worker, may play a role in the way individuals or groups process or safeguard information. These issues are summarized in Section 6.7. The H. 4 path coefficient was given in Figure 6–2.

No support was found for H. 6 which predicted less use of CMC in low equivocality environments. The factor analysis of the equivocality variable for H. 6 located two dimensions of the variable: task equivocality and inter-

unit equivocality. That is, one dimension of equivocality is associated with tasks that individuals perform in their jobs. The other type of equivocality is associated with relationships that exist among the individuals themselves involving coordinating work or activities or interpreting departmental policies. In neither category did the data indicate significant differences of CMC use among subjects stratified by low and high levels of both types of equivocality. The H. 6 path coefficients were provided above in Figure 6–3.

It is also evident that overall, the subjects in general use a variety of media, with preference for paper documents and face-to-face communication, as apparent in test results of H. 8 and H. 9 presented in Part 5. The author concludes that in terms of this population, equivocality in and of itself is an insufficient variable to predict media use. Again, the reasons why are unknown but could be related to the post hoc analysis offered in Section 6.3 where it explained that subjects' self-confidence may be a contributing factor. Also, it may suggest that individuals might adapt media to their own purposes in ways that are not specified by the model. These issues are addressed below in Section 6.7 which offers suggestions for further research.

The path coefficients for H. 7 provided in Figure 6–4 indicate a higher correlation between use of paper media than CMC media with effectiveness as the dependent variable in both low and high analyzability environments. Although these coefficients are statistically significant ($p \leq .01$), the overall results do not support the hypotheses as discussed above.

The coefficients for H. 8 illustrated in Figure 6–5 likewise show a higher correlation between effectiveness and use of paper media than CMC media, with effectiveness as the dependent variable in both low and high

Figure 6–4

Empirical Results of Path Relationships
Among Analyzability, Media Use, and Effectiveness
(H. 7)

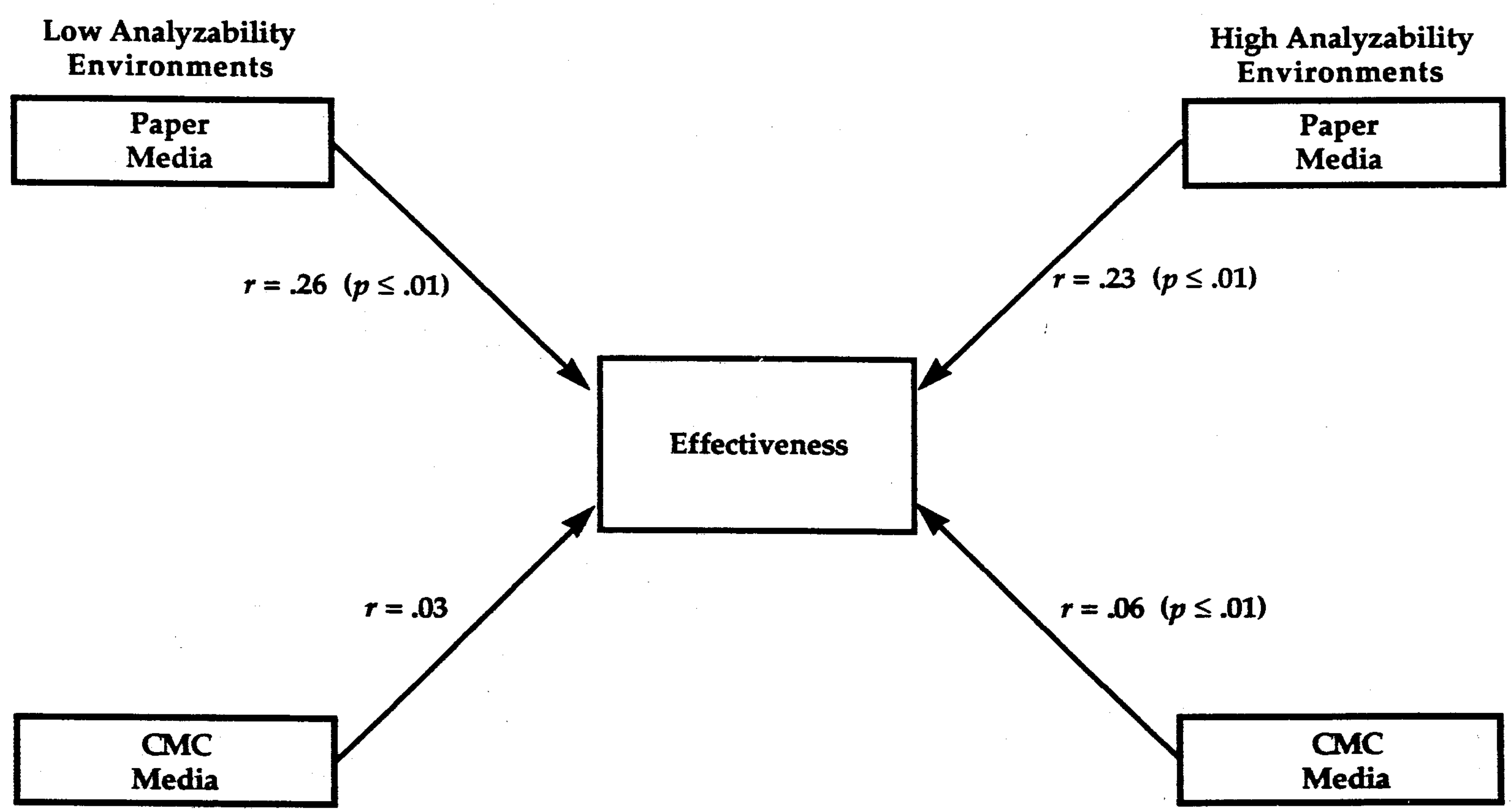
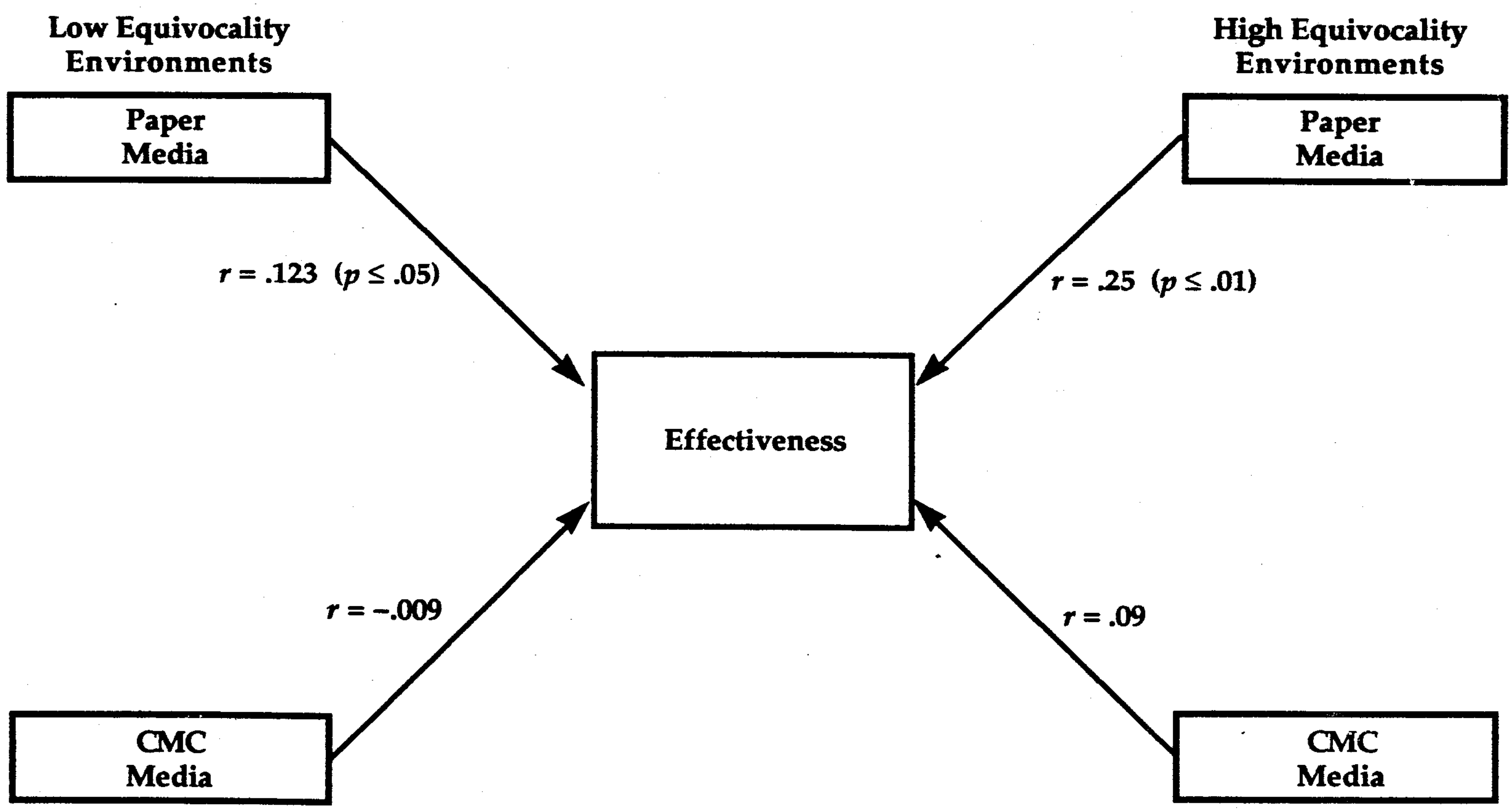


Figure 6–5

Empirical Results of Path Relationships Among Equivocality, Media Use, and Effectiveness (H. 8)



equivocality environments. Also, there is a very slight negative correlation between CMC use and effectiveness in environments characterized by low amounts of equivocality. However, the correlation is not significant. As with the previous test, there is nearly no variance explained by the independent variables, and the data do not support the hypothesis as discussed above.

The coefficients for the remaining two hypotheses, as given in Figure 6–6, also indicate that the data do not support the relationships as specified in the model. Also, there is almost no variance explained by the independent variables in either of the task environments.

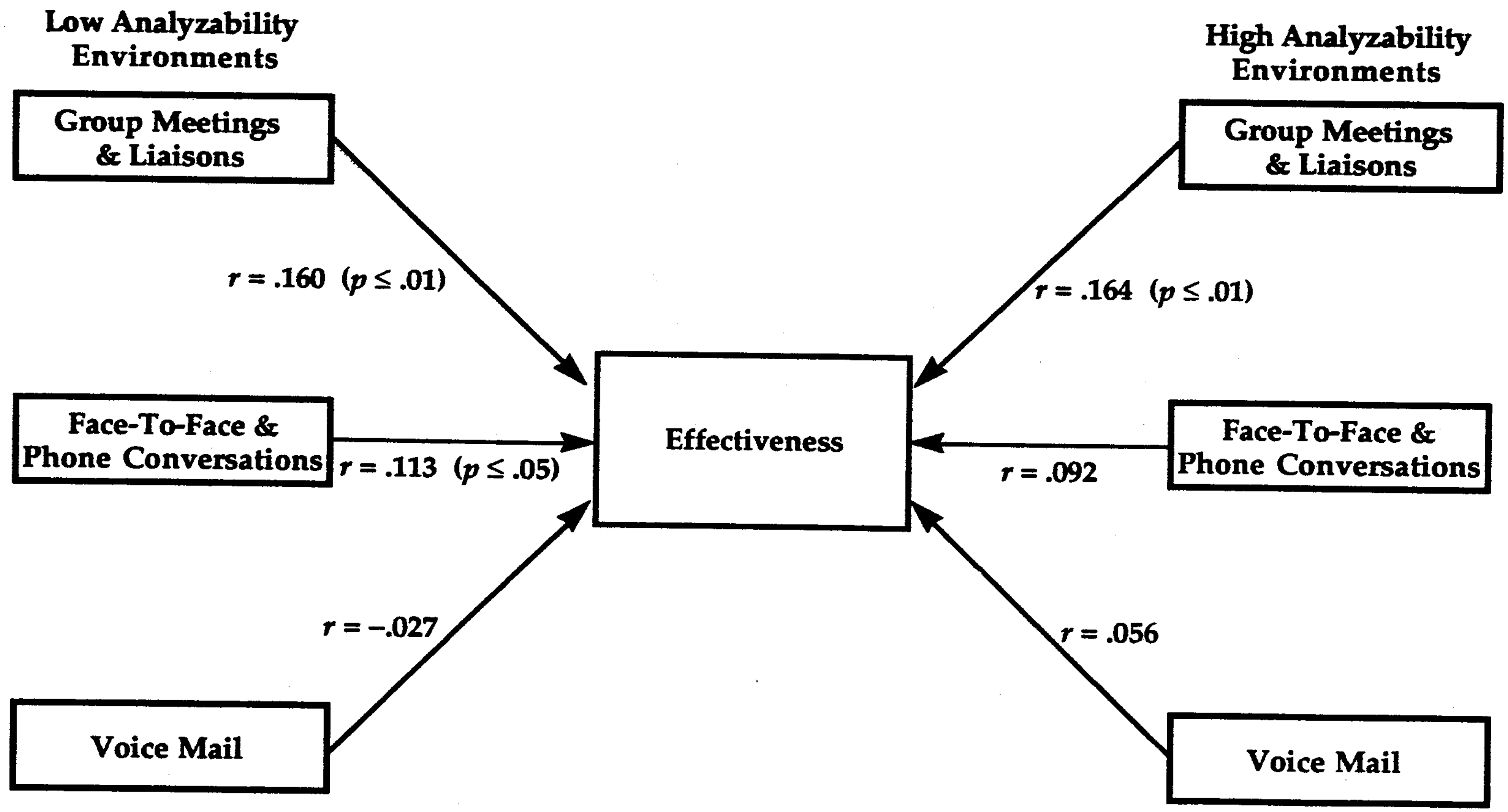
6.6 Limitations of the Study

Kerlinger (1986, Appendix D) stated that most problems involving social science research can usually be traced to lack of random sampling, to problems with measurement, or to statistical deficiencies. Because steps to ensure random sampling as explained in Part 4 were carefully followed, and because of the large sample size, the author is confident that the data do not suffer from external validity problems involving generalizability. As far as measurement and potential statistical deficiencies are concerned, the robust KMO measures for sampling adequacy and the relatively strong alpha coefficients for the scales' reliabilities mitigate concerns for problems associated with measurement or statistical adequacy.

However, one of the somewhat limiting aspects involved a low number of persons willing to cooperate in giving responses over the telephone. Realistically, however, this outcome is not inconsistent with Kerlinger's (1986) cautions regarding the use of telephone interviews:

Figure 6–6

Empirical Results of Path Relationships
Among Analyzability, Media Use, and Effectiveness
(H. 9 and H. 10)



> *Telephone surveys* [italics original] have little to recommend them, . . . [e]specially when the interviewer is unknown to the respondent, they [the researchers] are limited by possible nonresponse, uncooperativeness, and by reluctance to answer more than simple, superficial questions (Kerlinger, 1986, p. 380).

Such was the case in this study. It is difficult to know the subjects' reasons for reticence, but the author's ex post facto assumptions are threefold:

1) phone calls from strangers to ask questions about one's work habits are annoyances most people would avoid or minimize;
2) telephone surveys such as this compromise the anonymity of the respondent during data collection because the individual is requested by name, and this situation may reduce one's inclination to speak candidly;
3) the respondent may not feel willing to converse freely if the telephone environment is not private.

However, the author believes that the face-to-face meeting with the 27 AIAA members at the Reno conference helped to overcome some of the difficulties that were encountered in the telephone survey. Coupled with the fairly strong response rate to the mail portion of the study (over 1000 usable responses), the author does not anticipate that the research suffers from problems with validity or generalizability.

A second limitation of the study regards subject sampling: an inability to collect a large quantity of data from female subjects. However, this problem is inherent in an idiosyncrasy of the population rather than caused by a sampling error. That is, the overall AIAA membership is approximately

95% male, reflecting the preponderance of males in the aerospace engineering profession in the United States. The proportion of responses from females in this research ($N = 55$) represents 5.5% of the total number of responses as shown in Table 6–3. This sampling rate is highly consistent with the population, but it does not afford much opportunity for exploratory research involving gender comparisons. In summary, while there are some limitations to the research as described above, the author believes that they are neither gross nor numerous, and hence do not pose serious threats to either the generalizability of the findings or to the confidence one may have in the validity of the data.

6.7 Revisions to the Model as Suggestions for Future Research

In analyzing the results of the hypothesis tests to examine consistency of the findings between the variables in the model and the empirical evidence, the suggestions offered in this section tie the data obtained in the research to the model.

The data from this study yielded mixed results and provided only limited support for the Tushman and Nadler (1978) IP model. On the one hand, 40% of the proposed hypotheses were statistically significant (albeit one was in the opposite direction). Thus, the three hypotheses significant in the predicted direction do lend support for relations posited to exist among several of the variables. However, the operationalized model did not fully predict all of the significant findings. Also, the data do not provide statistically significant evidence that there are differences in media use

Table 6–3

SURVEY RESPONSE STATISTICS

Gender Summary Statistics

Responses by Gender

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Female	1	55	5.5	5.5	5.5
Male	2	939	93.3	94.5	100.0
Missing	9	12	1.2		
	Total	1006		100.0	100.0

regarding the proposed function of fit between IP requirements and IP capabilities as a strategy to increase overall effectiveness.

Overall, the data do confirm only some of the previous research of the IP model as applied in the aerospace environment. Both the Triscari (1984) study and this study suggest that the model is marginally descriptive in a few areas, such as in predicting the inverse relationship between analyzability and uncertainty as previously discussed. The model does not, however, predict adequately what individuals would do when making their media use decisions, as evidenced by the lack of support for the last four hypotheses that used effectiveness as the dependent variable. This is consistent with Markus' (1988) research that showed individuals do not always make the most effective media choices based solely on the criteria of objective efficiency.

One of the more interesting findings in the study regarded the significant result of the first hypothesis that was slightly in the opposite direction from what was predicted. This appears to be a new finding and does not comport with what we know about the relationship between variety and uncertainty as they are currently described in literature. As indicated in Section 6.3, an addition of the antecedent variables of education or levels of self-confidence in problem-solving abilities could provide a more accurate measure of the model's proposed relationship between variety and uncertainty. Such an addition is consistent with information provided by Schmitz and Fulk (1991) in their study of social influences and new media. They reported that they had concerns about the findings in their data because of a highly educated sample (i.e., 55% of the subjects held masters degrees or higher), similar to the 68% masters degrees or higher in this study's sample.

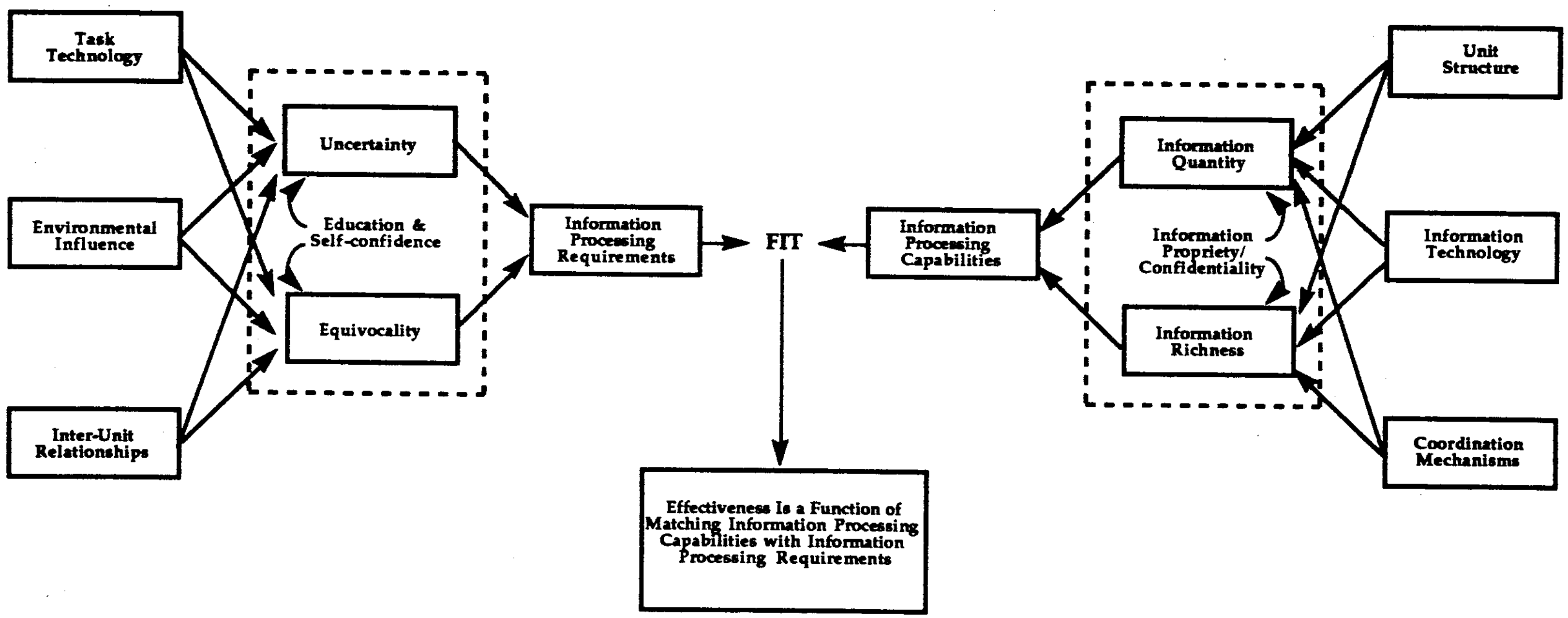
A second issue resulted from the test of the fourth hypothesis and its finding that the subjects were reticent to extend CMC use beyond the organization as confirmed by triangulation at the Reno AIAA group meeting. Again, to the best of the author's knowledge, viewing information as a proprietary commodity that must be safeguarded rather than shared, and regarding CMC as a potential breach in information security have not been specified as variables in the IP model. Further research using the model might consider ways to assess whether the dimensions of propriety and confidentiality of information influence the subjects' media choices. These dimensions may affect the quantity and richness of information that is sent.

Revisions to the model are depicted in Figure 6-7 which illustrates newly proposed relations among the variables. The dashed rectangle on the left indicates possible influence of education and self-confidence upon uncertainty and equivocality. The dashed rectangle on the right indicates possible effects of information propriety or confidentiality upon measures of information quantity and richness with respect to media use.

Regarding the elements of the information processing (IP) model, it could feasibly make a difference in media use and effectiveness measures if users of the media received prior instruction in some of the model's precepts before conducting the research. Of course, such instruction would shift the empirical approach toward a laboratory experiment and would possibly introduce problems in controlling for experimenter influence (Stacks & Hocking, 1992) and away from field-study methods which have so far constituted much of the research history involving variables in the IP model

Figure 6–7

Suggested Revisions to the Information Processing (IP) Model



(Balaguer, 1988; Daft & Lengel, 1986; Markus, 1988; Rice, 1992; Schmitz & Fulk, 1991; Trevino, Daft, & Lengel, 1990; Triscari, 1984; Tushman & Nadler, 1978).

Another problem with the model that needs to be examined more closely has to do with its assertion that certain media can be specified as optimal choices for a given communication depending on the task characteristics as explained in detail in Part 2: that media can be ranked in a sort of continuum according to their various capacities to provide immediate feedback with multiple context cues that support high levels of personalization and language variety, both verbal and nonverbal. The model further claims that effective managers should use "rich" media for the more equivocal and ambiguous tasks and "lean" media for the more unequivocal messages (Daft & Lengel, 1984; Daft & Lengel, 1986; Daft, Lengel, & Trevino, 1987; Trevino, et al., 1990a; Trevino, et al., 1990b). These prior studies, in finding some support for the model, would seem to indicate that media are unitary information processing devices and resist people's efforts at readapting them for their own purposes.

However, other researchers have published some evidence that may undermine this position by arguing for media's contextual adaptability. For example, Rice and Shook (1990) found that executives used certain media more than the IP model predicted. Fulk, Schmitz, and Steinfield (1990) pointed out that there are limitations to media richness theory as far as the rationality and objectivity of the individuals who make the media use choices. Fulk and her colleagues (1990) claimed that media use decisions do not occur in a vacuum, but instead are embedded within the social setting of an organization. The social presence model that they proposed was not based

solely on objective task characteristics for media use, but rather used subjective perceptions that were influenced by historical and social factors. Yates and Orlikowski (1992) also argued that communication is embedded in social process as opposed to isolated, rational actions.

Rice (1987) in his discussion of CMC and organizational innovation, stated that dimensions or characteristics of media are both multi-dimensional and contextual, so that some organizations used CMC for social communication while others used it only for tasks. This implies that one might find both rich, highly-informative and intimate CMC communication and limited, non-interactive face-to-face communication. Rice (1987) pointed out, for example, that one could expect to see low levels of interactivity in the face-to-face communication that might take place between a drill sergeant and a boot camp private in contrast to high levels of interactivity that might be exchanged via CMC by two persons who choose to disclose that information. He also found that experienced computer programmers who used CMC were more likely to rate it as acceptable for more personal tasks than were managers who had much less computer experience.

Rice and Danowski (1993) observed that how users conceptualized a medium affected how they used it. In the context of the voice mail (VM) medium where a computer-aided system is capable of handling digitized spoken messages, they specified voice answering (simple asynchronous storage of messages such as a telephone answering machine) as different from voice messaging. The voice messaging system was perceived to have a value added dimension because the messages could be "processed" rather than simply stored, such as in "broadcasting" messages to a group of recipients or

appending one's own response to a message and forwarding both to others. Rice and Danowski (1993) found that people were more likely to use voice answering in analyzable contexts and voice messaging in less analyzable contexts.

Marvin (1988), in her examination of technology and communication, stated that new electric media had the power to change the real or perceived social distances between individuals or groups, creating continuous concern for how new media rearrange or imperil social relationships, depending upon how they are used by people. As stated above, these views argue for media's contextual adaptability which is different from the IP model's claim that media can be arranged according to their task characteristics as opposed to the use to which people put them. This could in part be one of the explanations for the problematic lack of explained variance in this study.

Furthermore, as only 30% of the hypotheses were confirmed, one might ask whether or not the model itself can be kept since only parts of it are supported and inquire as to why fundamental aspects of the model are not working as predicted. One short answer is that, generally, social science research is based on models that are less well developed than the empirical models used in many of the physical sciences (Borman, 1980), and communication research is at best an imperfect science. But to address these questions in a more comprehensive way, however, it may be helpful to situate the study in the larger context of the current status of the discipline.

Because there is no grand, unified communication theory that is at the same time parsimonious, elegant, consistent, appropriate, heuristic, and powerful, researchers are forced to acknowledge that communication theories

are abstractions that cannot encompass all possible variables. As incomplete as they are, however, they do help us to organize and summarize knowledge and provide a way to focus observation, communicate ideas, and make predictions. And, part of the function of research is to permit the theories to undergo change, extension, growth, and development (Littlejohn, 1992).

With respect to the Tushman and Nadler (1978) information processing (IP) model, previous research—while acknowledging that the theory is well-developed conceptually—has found that the model suffers seriously both operationally and empirically (Balaguer, 1988; Rice, 1992, 1994; Triscari, 1984). Triscari (1984), in his study of research and development (R&D) units within the U.S. Air Force System Command, and Balaguer (1988), in her study of information processing in a highly technical computer-integrated manufacturing environment, both stated that a relationship was not indicated between degree of fit and unit effectiveness. They concluded that empirical data from their studies indicated that the Tushman and Nadler (1978) model was not adequate in explaining the empirical relationships and was not an adequate descriptive representation of the process of organizational design and effectiveness in actual field settings, similar to the data in this research. Also, the underlying message of media richness theory in Rice's (1992) study showed that, empirically, media richness explained just 10% of the variance, and even then only in the media rich condition. Rice (1994) later concluded that, assuming no measurement problems, this theory simply cannot sustain too much variability.

Consistent with the finding of these previous efforts, this study also failed to find significance in the central predictions of the model, that is, that

effectiveness can be increased by matching media use to task characteristics. However, theory development is an iterative process, and communication models are important for individuals who try to understand and/or predict human behavior by plotting, testing, and diagramming essential elements and fitting them into a structure (Borman, 1980). Research approaches evolve and change, and although no single study is an adequate basis upon which to reject or to not reject an entire theoretical formulation, there are now at least two previous studies—Balaguer (1988) and Triscari (1984)—in addition to this one, whose empirical results of the IP model in field settings indicate that it is not adequate in its present form. But, if the model is relevant to the purposes of some researchers who still see value in the parts of it that are working well, it probably will continue to undergo testing and development.

Whether or not the addition of new variables or modifications of existing ones, such as those discussed above and illustrated in Figure 6–7, will make marked changes in its explanatory power is a matter of speculation that this author regrets he is now unable to answer. At this point, the author does concur with findings of previous researchers using this model: that in its present form, the model is an inadequate descriptive tool. But, this current state of affairs does not necessarily preclude future modifications and testing of the model by those who remain interested in improving its usefulness, in an ongoing, iterative research process. For the present and immediate future, however, the author feels that future research possibilities using the data collected for this study may offer a promising new direction, the details of which are described in the section below.

6.8 Future Research Possibilities Using the Same Data

In his expectation of continuing research in the general area of organizational communication and media use, the author collected more data than minimally necessary within the scope of this dissertation's hypotheses tests. In part to re-examine some of the questions left unresolved as a result of the unsupported hypotheses previously discussed, and in part to work out new directions and prognosticate toward future research and analyses with what the researcher believes to be a robust set of data, the author offers below a preliminary approach for exploratory analysis of selected media variables that were not previously examined in the hypothesis tests discussed above.

The general direction will be to examine some yet unexplored dimensions of media use variables. Specifically, the exploration would involve multiple regression analysis to probe factors that may influence respondents' perceptions of certain media's applicability; that is, the inquiry will examine how people view media as opposed to how they use media. The expectation is that it may be possible to develop a better index of information capability as a way to analyze the role of media in organizational communication contexts.

In this case, data selected from questions 4–11 of the survey instrument will be used in a multiple regression analysis to investigate work-related communication as reported by the aerospace employees. The technique will involve summing the individual items (posed in a 5–point, Likert-scale format) across participants who fall in the higher ranges of CMC use (e.g., upper half, upper quartile, or upper decile) and then applying the items in a

multiple predictor case with "usefulness of the information" declared as the dependent variable. The independent variables initially entered into the equation would include the following seven dimensions:

1) importance of the information;
2) frequency of using the information source;
3) accuracy of the information;
4) specificity of the information;
5) sufficiency of the information;
6) degree of ease to obtain the information;
7) amount (load) of the information.

In this avenue of inquiry, rather than including large numbers of individuals who do not use new media, or who use them infrequently, this research would focus on those subjects who comprise a more "advanced" sample with respect to media sophistication and communication technology. The general approach would use a multiple regression analysis procedure to obtain the relative amounts of explained variance as the individual predictor variables itemized above are entered into the equation. Fit indices would suggest the variable model that is the best predictor of the criterion variable. As previously outlined, the expectation is that it may be possible to examine how people view media as well as how they use media in order to develop a new, and hopefully better, index of information capability as a way to analyze the role of communication media in the context of highly technical organizational environments.

6.9 Conclusion

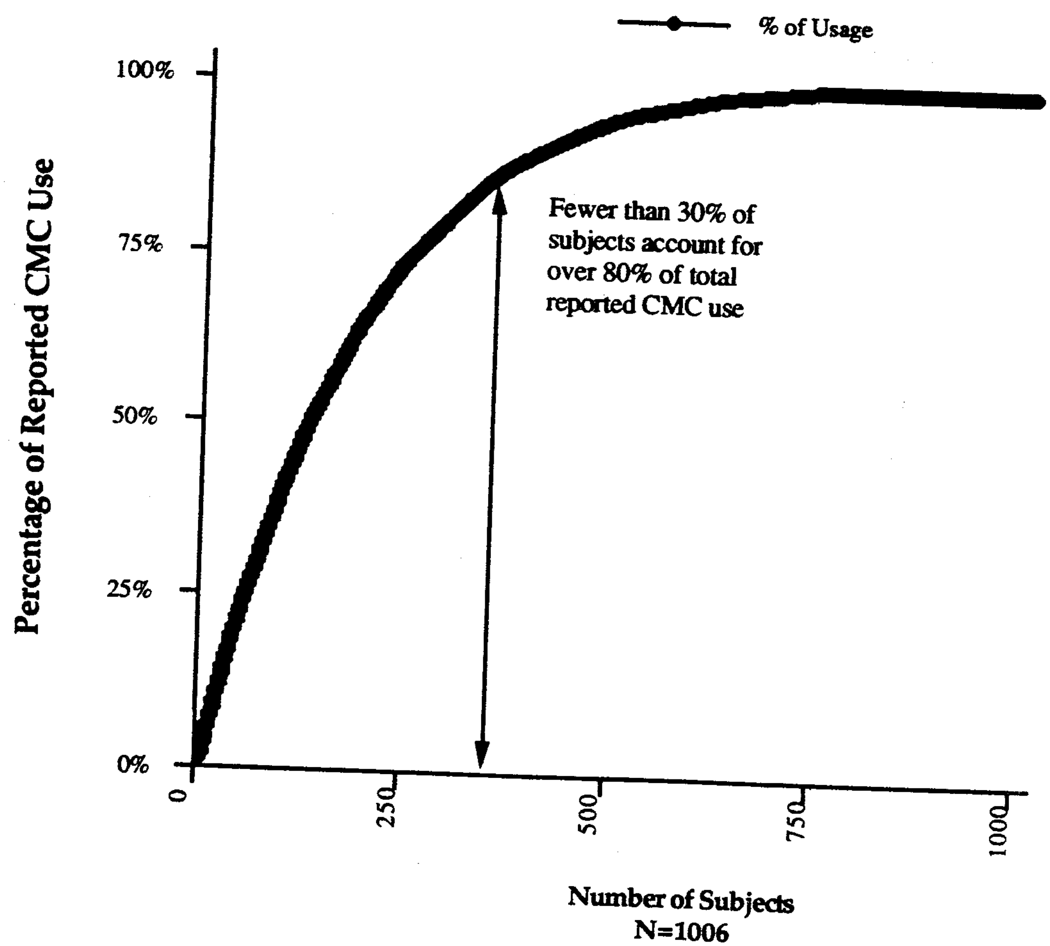
The robust response rate from a population of highly educated individuals who work in high-technology fields yielded a data set that lends support to the validity of the findings and to the generalizability of the results. However, a difficult question that is implied by the model still lies unanswered in these data and in the data of previous IP model research (Balaguer, 1988; Rice, 1992; Triscari, 1984): to what extent is media use a "rational" or conscious choice based on evaluation and interpretation? It is in this context that the IP model has its most severe limitation: the data do not indicate more than modest support for the model's predictive power, and the variance of the regressions of the last four hypotheses do not explain the difference between the "matched" and "unmatched" correlations of effectiveness and media use. Indeed, the results of the last four hypotheses could hardly be more random. This raises questions regarding the power of parts of the IP model as described in Section 6.6 which these data, unfortunately, are unable to help us answer. Based on the findings in this study, the author concludes that the model's most robust propositions involve the contextual variable of analyzability, coupled with modest support for the influence of uncertainty on CMC use. However, the proposed "fit" between IP requirements and capabilities as a necessary condition to influence overall effectiveness—the central tenet of the model—was not supported, and this is the most problematic issue as was discussed in Section 6.7.

More research seems desirable, and the next stage of the inquiry begun in this dissertation, as outlined in Section 6.8, will be to limit the research to CMC experts; that is, it will focus on the high-use CMC population rather

than including large numbers of individuals in the study who either do not use CMC at all or use it seldom. In this study, for example, less than 30% of the subjects accounted for about 80% of the total reported CMC use as is illustrated in Figure 6–8. Whereas the a priori hypotheses of this dissertation included all subjects in the analysis, the future analyses will center on expert CMC users as important information sources to help map trends in CMC use in the STI knowledge-diffusion process.

To undertake these concerns, the author suggests that future inquiries extend the focus toward perceptual measures associated with media, in addition to evaluating media use. While data on media use is necessary, there may be other factors that could enhance predictive power if integrated into future inquiries. As Rice (1987, 1992) indicated, it is important to think about the advantages and disadvantages of media channels to improve specifications of organizational communication and performance. This implies that we need to develop a better index of media capability. The index would include media use data, but extend beyond them, to encompass people's perceptions of media. As the so-called "information superhighway" continues to develop, changing with it the characteristics of media as we now know them, it becomes all the more important to alter how we assess communication media as differences among them diminish, and their similarities grow.

Figure 6–8
Overall Percentage of Reported CMC Use



REFERENCES CITED IN PART 6

Balaguer, N. S. (1988). CIM information technology utilization and organizational design: A field study on information processing. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Borman, E. G. (1980). Communication theory. Salem, WI: Sheffield.

Daft, R. L., & Lengel, R. H. (1984). Information richness: A new approach to managerial behavior and organization design. In B. M. Straw & L. L. Cummings (Eds.), Research in organizational behavior (pp. 191-233). Greenwich, CT: JAI Press.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. Management Science, 32, 554-571.

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection, and manager performance: Implications for information systems. Management Information Systems Quarterly, 11, 355-366.

Fulk, J., Schmitz, J., & Steinfield, C. W. (1990). A social influence model of technology. In J. Fulk & C. W. Steinfield (Eds.), Organizations and communication technology (pp. 117-140). Newbury Park, CA: Sage.

Galbraith, J. R. (1974). Organization design: An information processing view. Interfaces, 4, 28-36.

Kerlinger, F. N. (1986). Foundations of behavioral research (3rd ed.). Fort Worth: Holt, Rinehart and Winston.

Littlejohn, S. W. (1992). Theories of human communication (4th ed.). Belmont, CA: Wadsworth.

Markus, M. L. (1988). Information richness theory, managers, and electronic mail. Academy of Management Proceedings, Anaheim, CA.

Marvin, C. (1988). When old technologies were new: Thinking about electric communication in the late nineteenth century. New York: Oxford University Press.

Morgan, G. (1986). Images of organization. Beverly Hills, CA: Sage.

Pinelli, T. E. (1991). The relationship between the use of U.S. Government technical reports by U.S. aerospace engineers and scientists and selected institutional and sociometric variables (NASA Technical Memorandum 102774-6). NASA.

Pinelli, T. E., Glassman, M., Oliu, W. E., & Barclay, R. O. (1989). Technical communications in aerospace: Results of Phase 1 pilot study (No. TM-101534). NASA.

Rice, R. E. (1994, July 9). Media use. Personal communication.

Rice, R. E. (1987). Computer-mediated communication and organizational innovation. Journal of Communication, 37(4), 65-94.

Rice, R. E. (1992). Task analyzability, use of new media, and effectiveness: A multi-site exploration of media richness. Organization Science, 3(4), 475-500.

Rice, R. E., & Danowski, J. A. (1993). Is it really just like a fancy answering machine? Comparing semantic networks of different types of voice mail users. Journal of Business Communication, 30(4), 369-397.

Rice, R. E., & Shook, D. E. (1990). Voice messaging, coordination, and communication. In J. Galegher, R. Kraut, & C. Egido (Eds.), Intellectual teamwork: Social and technological foundations of cooperative work (pp. 327-350). Hillsdale, NJ: Lawrence Erlbaum.

Schmitz, J., & Fulk, J. (1991). Organizational colleagues, media richness, and electronic mail: A test of the social influence model of technology use. Communication Research, 18(4), 487-523.

Simon, H. A. (1976). Administrative behavior: A study of decision-making processes in administrative organization (3rd ed.). New York: Free Press.

Stacks, D. W., & Hocking, J. E. (1992). Essentials of communication research. New York: HarperCollins.

Trevino, L. K., Daft, R. L., & Lengel, R. H. (1990). Understanding managers' media choices: A symbolic interactionist perspective. In J. Fulk & C. Steinfield (Eds.), Organizations and communication technology (pp. 71-94). Newbury Park, CA: Sage.

Trevino, L. K., Lengel, R., & Bodensteiner, W. (1990). The richness imperative and cognitive style: The role of individual differences in media choice behavior. Management Communication Quarterly, 4(2), 176-197.

Triscari, T. (1984). Organizations and information processing: A field study of research and development units within the United States Air Force systems command. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Tushman, M. L., & Nadler, D. A. (1978). Information processing as an integrating concept in organizational design. Academy of Management Review, 3, 613-624.

Yates, J., & Orlikowski, W. J. (1992). Genres of organizational communication: A structurational approach to studying communication and media. Academy of Management Review, 17, 299-326.

PART 7

LIST OF REFERENCES

Albrecht, T. L., & Ropp, V. (1982). The study of network structuring in organizations through the use of method triangulation. The Western Journal of Speech Communication, 46, 162–178.

Allen, T. J., & Hauptman, O. (1987). The influence of communication technology on organizational structure. Communication Research, 14, 575–587.

Applegate, L. M., Cash, J. I., & Mills, D. Q. (1988). Information technology and tomorrow's manager. Harvard Business Review, 88, 128–136.

Babbie, E. (1990). Survey research methods (2nd ed.). Belmont, CA: Wadsworth.

Babbie, E. R. (1979). The practice of social research (2nd ed.). Belmont, CA: Wadsworth.

Balaguer, N. S. (1988). CIM information technology utilization and organizational design: A field study on information processing. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Balaguer, N. S., & Leifer, R. P. (1989). Information processing capabilities and organizational design: A model and field study. (Working paper), Harvard Business School, Cambridge, MA, and Rensselaer Polytechnic Institute School of Management, Troy, NY.

Baligh, N. M., & Burton, R. M. (1981). Describing and designing organization structure and processes. International Journal of Policy Analysis and Information Systems, 5, 251–266.

Becker, S. W., & Baloff, N. (1969). Organization structure and complex problem solving. Administrative Science Quarterly, 14, 260–271.

Behan, K., & Holmes, D. (1986). Understanding information technology: Text, readings, and cases. Englewood Cliffs, NJ: Prentice-Hall.

Beniger, J. R. (1991). Information society and global science. In C. Dunlop & R. Kling (Eds.), Computerization and controversy: Value conflicts and social choices (pp. 383–397). San Diego: Academic Press.

Bikson, T. K., & Gutek, B. A. (1983). Advanced office systems: An empirical look at utilization and satisfaction (No. N–197–NSF). Rand.

Blalock, H. M. (1979). Social statistics (2nd ed.). New York: McGraw-Hill.

Blandin, J. S., & Brown, W. B. (1977). Uncertainty and management's search for information. IEEE transactions on Engineering Management, EM–24, 114–119.

Borman, E. G. (1980). Communication theory. Salem, WI: Sheffield.

Bourgeois, L. J. (1985). Strategic goals, perceived uncertainty, and economic performance in volatile environments. Academy of Management Journal, 28, 548–573.

Bradley, J. (1972). Nonparametric statistics. In R. Kirk (Eds.), Statistical issues: A reader for the behavioral sciences (Sel. 9.1). Monterey, CA: Brooks/Cole.

Burns, A. (Ed.). (1984). New information technology. New York: Halsted.

Burns, T., & Stalker, G. M. (1961). The management of innovation. London: Tavistock.

Cattell, R. B. (Ed.). (1966). Handbook of multivariate experimental psychology. Chicago: Rand McNally.

Checkland, P. B. (1986). Systems theory and information systems. In B. Langefors, A. A. Verrijn-Stuart, & G. Bracchi (Eds.), Trends in information systems (pp. 327–339). New York: Elsevier.

Chesebro, J. W., & Bonsall, D. G. (1989). Computer-mediated communication: Human relationships in a computerized world. Tuscaloosa: University of Alabama Press.

Cravens, D. W. (1970). An exploratory analysis of individual information processing. Management Science(16), B656–670.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. Psychometrika, 16, 297–334.

Cummings, T. G. (1980). Systems theory for organizational development. New York: Wiley.

Daft, R. L., & Huber, G. P. (1987). How organizations learn: A communication framework. Research in the Sociology of Organizations, 5, 1–36.

Daft, R. L., & Lengel, R. H. (1984). Information richness: A new approach to managerial behavior and organization design. In B. M. Straw & L. L. Cummings (Eds.), Research in organizational behavior (pp. 191–233). Greenwich, CT: JAI Press.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. Management Science, 32, 554-571.

Daft, R. L., & Macintosh, N. B. (1981). A tentative exploration into the amount and equivocality of information processing in organizational work units. Administrative Science Quarterly, 26, 207–224.

Daft, R. L., & Weick, K. E. (1984). Toward a model of organizations as interpretation systems. Academy of Management Review, 9, 284–295.

Daft, R. L., & Wiginton, J. C. (1979). Language and organization. Academy of Management Review, 4, 179–191.

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection, and manager performance: Implications for information systems. Management Information Systems Quarterly, 11, 355–366.

Danowski, J. A., & Edison-Swift, P. (1985). Crisis effects on intraorganizational computer-based information. Communication Research, 12, 251–270.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. Management Science, 35, 982–1003.

Denzin, N. K. (1970a). Sociological methods: A sourcebook. Chicago: Aldine.

Denzin, N. K. (1970b). The research act: A theoretical introduction to sociological methods. Chicago: Aldine.

Diener, E., Lusk, R., DeFour, D., & Flax, R. (1980). Deindividuation: Effects of group size, density, number of observers, and group member similarity on self-consciousness and disinhibited behavior. Journal of Personality and Social Psychology, 39, 449–459.

Dill, W. R. (1958). Environment as an influence on managerial autonomy. Administrative Science Quarterly, 2, 409–443.

Dillman, D. A. (1978). Mail and telephone surveys: The total design method. New York: Wiley.

Downey, H. K., Hellriegel, D., & Slocum, J. R. (1975). Environmental uncertainty: The construct and the application. Administrative Science Quarterly, 20, 613–629.

Drazin, R., & Van de Ven, A. H. (1985). Alternative forms of fit in contingency theory. Administrative Science Quarterly, 30, 514–539.

Dubin, R. (1959). The sociology of industrial relations. Englewood Cliffs, NJ: Prentice-Hall.

Duncan, R. B. (1972). Characteristics of organizational environments and perceived uncertainty. Administrative Science Quarterly, 17, 313–327.

Duncan, R. B. (1973). Multiple decision-making structures in adapting to environmental uncertainty: The impact on organizational effectiveness. Human Relations, 26(3), 273–291.

Ferguson, G. A. (1981). Statistical analysis in psychology and education (5th ed.). New York: McGraw-Hill.

Finholt, T., Sproull, L., & Kiesler, S. (1990). Communication and performance in ad hoc task groups. In J. Galegher, R. Kraut, & C. Egido (Eds.), Intellectual teamwork: Social and technological foundations of cooperative work (pp. 291–325). Hillsdale, NJ: Lawrence Erlbaum.

Ford, J. D., & Slocum, J. W. (1977). Size, technology, environment and the structure of organizations. Academy of Management Review, 2, 561–575.

Fulk, J., & Ryu, D. (1990). Perceiving electronic mail systems: A partial test of social information processing model of communication media in organizations. ICA, Dublin.

Fulk, J., Schmitz, J., & Steinfield, C. W. (1990). A social influence model of technology. In J. Fulk & C. W. Steinfield (Eds.), Organizations and communication technology (pp. 117-140). Newbury Park, CA: Sage.

Galbraith, J. R. (1973). Designing complex organizations. Reading, MA: Addison-Wesley.

Galbraith, J. R. (1974). Organization design: An information processing view. Interfaces, 4, 28–36.

Glass, G., Peckham, P., & Sanders, J. (1972). Consequences of failure to meet assumptions underlying the fixed effects analysis of variance and covariance. Review of Educational Research, 42, 237–288.

Gratz, R. D., & Salem, P. J. (1984). Technology and the crisis of self. Communication Quarterly, 32, 98–103.

Groves, R. M., & Kahn, R. L. (1979). Surveys by telephone. New York: Academic Press.

Hage, J., Aiken, M., & Marrett, C. B. (1971). Organization structure and communications. American Sociological Review, 36, 860–871.

Hammer, M., & Mangurian, G. E. (1987). The changing value of communications technology. Sloan Management Review, 28, 65–71.

Hernon, P., & Pinelli, T. E. (1992). Scientific and technical policy and the competitive position of the U.S. aerospace industry. (AIAA–92–0796). Washington, DC: AIAA.

Hiltz, S. R., & Turoff, M. (1978). The network nation: Human communication via computer. Reading, MA: Addison-Wesley.

Hiltz, S. R., Turoff, M., & Johnson, K. (1981). Effect of structure, task, and individual attributes on consensus in computerized conferences. In The IFIP TC–6 International Symposium on Computer Message Systems, (pp. 91–102). Ottawa, Canada: North-Holland Publication Co.

Hjalmarsson, A., Oestreicher, L., & Waern, Y. (1989). Human factors in electronic mail system design. Behaviour & Information Technology, 8, 461–474.

Hoinville, G., & Jowell, R. (1978). Survey research practice. London: Heinemann.

Huber, G. P. (1984). The nature and design of post-industrial organizations. Management Science, 30, 928–951.

Hurt, H. T., & Hibbard, R. (1989). The systematic measurement of the perceived characteristics of information technologies I: Microcomputers as innovations. Communication Quarterly, 37, 214–222.

Kaiser, H. F. (1974). An index of factorial simplicity. Psychometrika, 39, 31–36.

Katz, D., & Kahn, R. L. (1966). The social psychology of organizations. New York: Wiley.

Kennedy, J. (1993, November 27). Subject: Book outline. E-mail message.

Kennedy, J. M., Pinelli, T. E., Hecht, L. F., & Barclay, R. O. (1994). An analysis of the transfer of scientific and technical communications in aerospace. Annual Meeting of the American Sociological Association, Los Angeles.

Kerlinger, F. N. (1986). Foundations of behavioral research (3rd ed.). Fort Worth: Holt, Rinehart and Winston.

Kiesler, S., Siegel, J., & McGuire, T. W. (1984). Social psychological aspects of computer-mediated communication. American Psychologist, 39, 1123–1134.

Kim, J., & Mueller, C. W. (1978). Introduction to factor analysis. Beverly Hills, CA: Sage.

Kleinbaum, D. G., & Kupper, L. L. (1978). Applied regression analysis and other multivariable methods. North Scituate, MA: Duxbury Press.

Kling, R. (1980). Social analysis of computing: Theoretical perspectives in recent empirical research. Computing Surveys, 12, 61–110.

Kraemer, K. L., & Pinsonneault, A. (1990). Technology and groups: Assessment of the empirical research. In J. Galegher, R. Kraut, & C. Egido (Eds.), Intellectual teamwork: Social and technological foundations of cooperative work (pp. 375–405). Hillsdale, NJ: Lawrence Erlbaum.

Kraut, R. E., Lewis, S. H., & Swezey, L. W. (1982). Listener responsiveness and the coordination of conversation. Journal of Personality and Social Psychology, 43, 718–731.

Lawrence, P. R., & Lorsch, J. W. (1967a). Differentiation and integration in complex organizations. Administrative Science Quarterly, 12, 1–47.

Lawrence, P. R., & Lorsch, J. W. (1967b). Organization and environment. Homewood, IL: Richard Irwin.

Leifer, R. (1988). Matching computer-based information systems with organizational structures. Management Information Systems Quarterly, 12, 63–73.

Leifer, R., & Huber, G. P. (1977). Relations among perceived environmental uncertainty, organizational structure, and boundary-spanning behavior. Administrative Science Quarterly, 22, 235–247.

Leifer, R., & Triscari, T. (1987). Organizational information processing characteristics and computer based information systems design (Working paper), School of Management, Rensselaer Polytechnic Institute, Troy, NY.

Lind, M. R., & Zmud, R. W. (1991). The influence of a convergence in understanding between technology providers and users on information technology innovativeness. Organization Science, 2(2), 195–217.

Lissitz, R. W., & Green, S. B. (1975). Effect of the number of scale points on reliability. Journal of Applied Psychology, 60(1), 10–13.

Littlejohn, S. W. (1992). Theories of human communication (4th ed.). Belmont, CA: Wadsworth.

Luyken, G. M. (1987). New compunications [sic] technology. In J. D. Slack & F. Fejes (Eds.), The ideology of the information age (pp. 220–242). Norwood, NJ: Ablex.

Mader, C. (1979). Information systems: Technology, economics, applications, management (2nd ed.). Chicago: Science Research Associates.

Mandell, S. L. (1989). Computers and information processing: The complete course (5th ed.). St. Paul: West.

Markus, M. L. (1988). Information richness theory, managers, and electronic mail. Academy of Management Proceedings, Anaheim, CA.

Marschak, J., & Radner, R. (1972). Economic theory of teams. New Haven: Yale University Press.

Marvin, C. (1988). When old technologies were new: Thinking about electric communication in the late nineteenth century. New York: Oxford University Press.

McCullough, P. (1984). Fundamentals of IBM computer systems. Chicago: Science Research Associates.

McDonough III, E. F., & Leifer, R. (1983). Using simultaneous structures to cope with uncertainty. Academy of Management Journal, 26, 727–735.

Miles, R. E., & Snow, C. C. (1978). Organization strategy structure and process. New York: McGraw-Hill.

Miller, E. J., & Rice, A. K. (1967). Systems of organizations. London: Tavistock.

Mintzberg, H. (1983). Structure in fives: Designing effective organizations. Englewood Cliffs, NJ: Prentice-Hall.

Morgan, G. (1986). Images of organization. Beverly Hills, CA: Sage.

Morse, J. J., & Lorsch, J. W. (1970). Beyond theory Y. Harvard Business Review, 62(1), 1–8.

Norušis, M. J. (1990). SPSS Base system user's guide (4th ed.). Chicago: SPSS, Inc.

Nunnally, J. (1978). Psychometric theory (2nd ed.). New York: McGraw-Hill.

O'Reilly, C. A. (1982). Variations in decision makers' use of information sources: The impact of quality and accessibility of information. Academy of Management Journal, 25, 756–771.

Perrow, C. (1967). A framework for the comparative analysis of organizations. American Sociological Review, 32, 194–208.

Pinelli, T. E. (1991). The relationship between the use of U.S. Government technical reports by U.S. aerospace engineers and scientists and selected institutional and sociometric variables. (NASA Technical Memorandum 102774-6). NASA.

Pinelli, T. E., Glassman, M., Oliu, W. E., & Barclay, R. O. (1989). Technical communications in aerospace: Results of Phase 1 pilot study. (TM-101534). NASA.

Pinelli, T. E., Kennedy, J. M., & Barclay, R. O. (1994). Information product use among aerospace engineers and scientists. (Report Number 21). NASA.

Piturro, M. C. (1989). Computer conferencing: Brainstorming across time and space. Management Review, 78, 43–50.

Quarterman, J. S. (1990). The matrix: Computer networks and conferencing systems worldwide. Bedford, MA: Digital Press.

Quarterman, J. S., & Hoskins, J. C. (1986). Notable computer networks. Communications of the ACM, 29, 932–971.

Quinn, R. E., & Cameron, K. (1983). Organizational life cycles and shifting criteria of effectiveness: Some preliminary evidence. Management Science, 29, 33–51.

Rademacher, R. A., & Gibson, H. L. (1983). An introduction to computers and information systems. Cincinnati: South-Western.

Randolph, W., & Finch, F. (1977). The relationship between organizational technology and the direction and frequency dimensions of task communications. Human Relations, 30, 1131–1145.

Rice, R. E. (1987). Computer-mediated communication and organizational innovation. Journal of Communication, 37(4), 65-94.

Rice, R. E. (1992a). Task analyzability, use of new media, and effectiveness: A multi-site exploration of media richness. Organization Science, 3(4), 475-500.

Rice, R. E. (1992b). Network analysis and computer-mediated communication systems. In S. W. &. J. Galaskiewicz (Eds.), Communication yearbook (pp. 1–19). Newbury Park, CA: Sage.

Rice, R. E. (1994, July 9). Media use. Personal communication.

Rice, R. E., & Danowski, J. A. (1993). Is it really just like a fancy answering machine? Comparing semantic networks of different types of voice mail users. Journal of Business Communication, 30(4), 369-397.

Rice, R. E., & Love, G. (1987). Electronic emotion: Socioemotional content in a computer-mediated communication network. Communication Research, 14(1), 85–108.

Rice, R. E., & Shook, D. E. (1990). Voice messaging, coordination, and communication. In J. Galegher, R. Kraut, & C. Egido (Eds.), Intellectual teamwork: Social and technological foundations of cooperative work (pp. 327-350). Hillsdale, NJ: Lawrence Erlbaum.

Rummel, R. J. (1970). Applied factor analysis. Evanston, IL: Northwestern University Press.

Scheirer, M. F., & Carver, C. S. (1977). Self-focused attention and the experience of emotion: Attraction, repulsion, elation, and depression. Journal of Personality and Social Psychology, 35, 625–636.

Schmitz, J., & Fulk, J. (1990). The role of organizational colleagues in media selection. ICA, Dublin.

Schmitz, J., & Fulk, J. (1991). Organizational colleagues, media richness, and electronic mail: A test of the social influence model of technology use. Communication Research, 18(4), 487-523.

Seashore, S., Indik, B., & Georgopoulos, B. (1960). Relationships among criteria of job performance. Journal of Applied Psychology, 44, 195–202.

Shannon, C. E., & Weaver, W. (1963). The mathematical theory of communication. Urbana: University of Illinois Press.

Short, J., Williams, E., & Christie, B. (1976). The social psychology of telecommunications. London: Wiley.

Siegel, J., Dubrovsky, V., Kiesler, S., & McGuire, T. (1986). Group processes in computer-mediated communication. Organizational behavior and human decision processes, 37, 157–187.

Siegel, S. (1956). Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill.

Silver, G. A., & Silver, M. L. (1986). Computers and information processing. New York: Harper and Row.

Simon, H. A. (1962). The architecture of complexity. Proceedings of the American Philosophical Society, 106, 467–482.

Simon, H. A. (1976). Administrative behavior: A study of decision-making processes in administrative organization (3rd ed.). New York: Free Press.

Spitzer (1986). Writing style in computer conferences. IEEE Transactions on Professional Communication, PC 29(1), 19–22.

Sproull, L., & Kiesler, S. (1986). Reducing social context cues: Electronic mail in organizational communication. Management Science, 32(11), 1492–1512.

SPSS. (1992). Advanced techniques: Regression. Chicago: SPSS Inc.

Stacks, D. W., & Hocking, J. E. (1992). Essentials of communication research. New York: HarperCollins.

Steinfield, C. W. (1986). Computer-mediated communication in an organizational setting: Explaining task-related and socioemotional uses. In M. L. McLaughlin (Eds.), Communication yearbook 10 (pp. 777–804). Beverly Hills, CA: Sage.

Strasser, S., & Denniston, O. L. (1979). A comparative analysis of goal and system models designed to evaluate health organization effectiveness. Academy of Management Proceedings, pp. 342–346.

Szilagyi, A. D., & Wallace, M. J. (1987). Organizational behavior and performance (4th ed.). Glenview, IL: Scott, Foresman.

Thompson, J. D. (1967). Organizations in action. New York: McGraw-Hill.

Tichy, N. M. (1983). Managing strategic change. New York: Wiley.

Trevino, L. K., Daft, R. L., & Lengel, R. H. (1990). Understanding managers' media choices: A symbolic interactionist perspective. In J. Fulk & C. Steinfield (Eds.), Organizations and communication technology (pp. 71-94). Newbury Park, CA: Sage.

Trevino, L. K., Lengel, R., & Bodensteiner, W. (1990). The richness imperative and cognitive style: The role of individual differences in media choice behavior. Management Communication Quarterly, 4(2), 176-197.

Triscari, T. (1984). Organizations and information processing: A field study of research and development units within the United States Air Force systems command. Unpublished doctoral dissertation, Rensselaer Polytechnic Institute, Troy, NY.

Turski, W. M. (1985). Informatics: A propaedeutic view (B. Osuchowska, Trans.). (2nd ed.). New York: Elsevier.

Tushman, M. L., & Nadler, D. A. (1978). Information processing as an integrating concept in organizational design. Academy of Management Review, 3, 613-624.

Tyler, B. B., Bettenhausen, K. L., & Daft, R. L. (1989). The use of low and high rich information sources and communication channels in developing and implementing competitive business strategy. Academy of Management Proceedings (pp. 245–249).

Van de Ven, A., Delbecq, A., & Koenig, R. (1976). Determinants of coordination modes within organizations. American Sociological Review, 41, 322–338.

Webb, E. T., Campbell, D. T., Schwartz, R. D., Sechrest, L., & Grove, J. B. (1981). Nonreactive measures in the social sciences (2nd ed.). Boston: Houghton Mifflin.

Weick, K. E. (1979). The social psychology of organizing (2nd ed.). Reading, MA: Addison Wesley.

Withey, M., Daft, R. L., & Cooper, W. H. (1983). Measures of Perrow's work unit technology: An empirical assessment and a new scale. Academy of Management Journal, 26(1), 45-63.

Woodward, J. (1965). Industrial organization: Theory and practice. London: Oxford University Press.

Yates, J., & Orlikowski, W. J. (1992). Genres of organizational communication: A structurational approach to studying communication and media. Academy of Management Review, 17, 299-326.

Young, R. K., & Veldman, D. J. (1981). Introductory statistics for the behavioral sciences (4th ed.). New York: Holt, Rinehart and Winston.

Zmud, R. W. (1990). Opportunities for strategic information manipulation through new information technology. In J. Fulk & C. Steinfield (Eds.), Organizations and communication technology (pp. 95–116). Newbury Park, CA: Sage.

Zmud, R., Lind, M., & Young, F. (1990). An attribute space for organizational communication channels. Information Systems Research, 1(4), 440–457.

APPENDIX A

RESEARCH COMMISSION FROM NASA/DoD KNOWLEDGE DIFFUSION RESEARCH PROJECT

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia
23665-5225

NASA

Reply to Attn of 180A

November 5, 1991

Mr. Daniel Murphy
SUNY Center of Technology
Arts and Sciences
PO Box 3050
Utica, NY 13504-3050

Dear Dan:

We would be pleased for you to undertake your dissertation as part of the NASA/DoD Aerospace Knowledge Diffusion Research Project. The use of computer mediated communication by U.S. aerospace engineers and scientists is extremely relevant to our work. It is a topic that is worthy of support.

Our research project is a cooperative effort that is sponsored by the NASA, Director of the Scientific and Technical Information Division (Code JTT), the DoD, Office of the Assistant Secretary of the Air Force, Deputy for Scientific and Technical Information, and the Administrator, Defense Technical Information Center (DTIC). The project is a joint effort of the Indiana University Center for Survey Research and the NASA Langley Research Center. This 4-phase project is providing descriptive and analytical data regarding the flow of scientific and technical information (STI) at the individual, organizational, national, and international levels.

Under the auspices of the Project, we would agree to provide a sample drawn from a list of U.S. aerospace engineers and scientists belonging to a professional society and would typeset and provide printed copies of a questionnaire. Data input and processing would be provided through the Indiana University Center for Survey Research. We might be able to provide postage using NASA franked envelopes. In turn, we ask that you agree to allow us to include your dissertation as a report issued under the NASA/DoD Aerospace Knowledge Diffusion Research Project.

I would also strongly encourage you to apply to the Society for Technical Communication (STC) for a research grant to support your dissertation. A copy of the guidelines are enclosed. Please familiarize yourself with the guidelines before preparing your proposal. An informative abstract, not to exceed one page, must accompany each proposal. The abstract must contain the study's purpose and significance to technical communication and to the Society; a description of the methodology; a strategy for collecting, presenting, and analyzing the data; and a plan for documenting the results.

Please consider the following important points. Requests for funding cannot exceed $4,000.00. In addition to a final report, the Society demands the right of first refusal to publish a manuscript that documents the results of your work. The Society would prefer that proposals not include indirect costs. The Society will not pay indirect costs in excess of 8 percent.

I look forward to hearing from you and to you working with us. Please contact me if you have questions or need additional information. I can be reached by mail at the NASA Langley Research Center at Mail Stop 180A, by telephone at (804) 864-2491, by fax at (804) 864-8311, and by E-mail at tompin@.teb.larc.nasa.gov.

Sincerely,

Thom Pinelli

Thomas E. Pinelli, Ph.D.
Assistant to the Chief
Research Information and
Applications Division

Enclosures

cc:
Dr. John M. Kennedy
Center for Survey Research
1022 East Third Street
Bloomington, IN 47401

Mr. Walter R. Blados
Code JTT
National Aeronautics and Space Administration
Washington, DC 20546

society for technical communication

901 N. Stuart Street, Suite 304, Arlington, VA 22203-1822
(703) 522-4114 FAX (703) 522-2075

William C. Stolgitis
Executive Director

June 10, 1992

Mr. Daniel J. Murphy
9 Hollywood Drive
Whitesboro, NY 13429-2308

Dear Mr. Murphy:

I am happy to inform you that the STC board of directors has approved your research grant proposal, "Research on Computer-Mediated Communication." Your project has been funded for $4,000.

The <u>Guidelines for Research Grants</u> (AD-51-88) explain your responsibilities and how to obtain reimbursement for your expenses. The maximum rate allowed for indirect costs is 8% of this grant.

Congratulations and best of success with your research.

Sincerely,

William C. Stolgitis

William C. Stolgitis
Executive Director

Enclosure

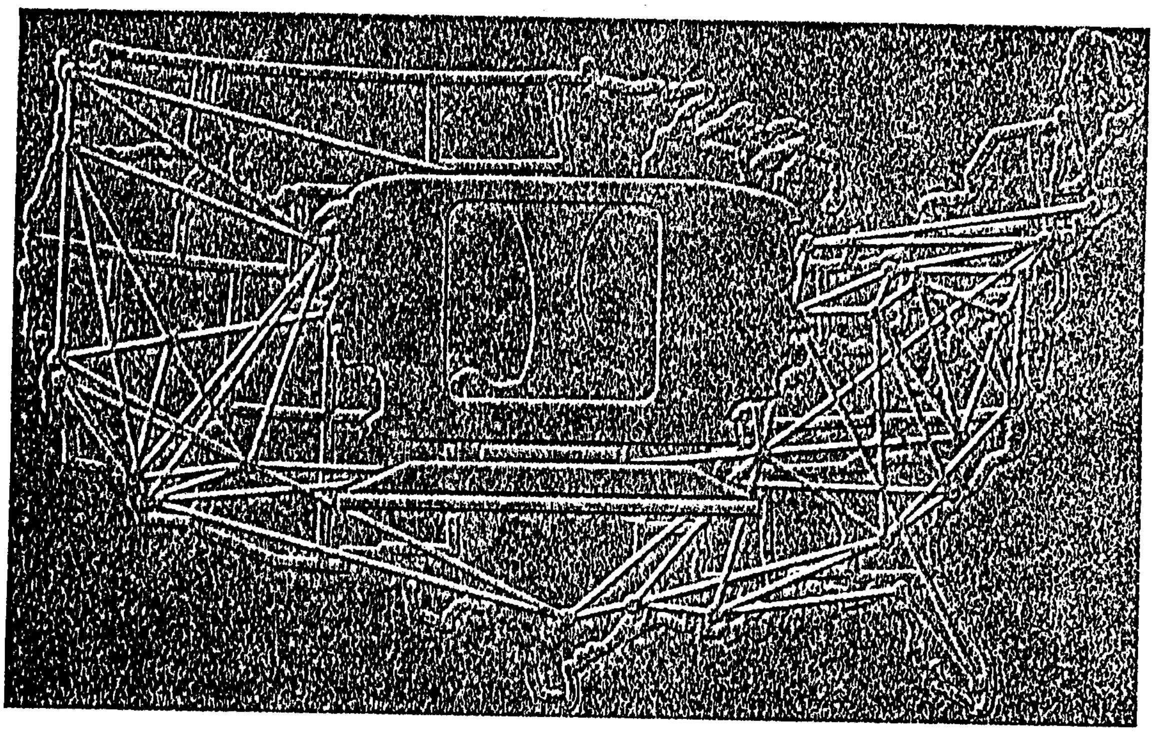
cc: C. Velotta

APPENDIX B

COPY OF SURVEY INSTRUMENT

Phase 1 of the NASA/DoD Aerospace Knowledge Diffusion Research Project

Computer-Mediated Communication (CMC) and the Communication of Technical Information in Aerospace



Sponsored by the National Aeronautics and Space Administration and the Department of Defense with the cooperation of Indiana University, Rensselaer Polytechnic Institute, the State University of New York Institute of Technology at Utica/Rome, and the American Institute of Aeronautics and Astronautics (AIAA)

NATURE OF THE WORK

1. How accurately do the following statements describe the work performed in your department? (Please note: Your manager is a member of your department.)

		Strongly Disagree				Strongly Agree
a.	The work is routine	1	2	3	4	5
b.	There is an ordered sequence to be followed in carrying out the work	1	2	3	4	5
c.	The tasks performed differ greatly from day-to-day	1	2	3	4	5
d.	It is difficult to specify a sequence for carrying out the work	1	2	3	4	5
e.	We use repetitive activities in doing the work	1	2	3	4	5
f.	Established procedures exist for most work	1	2	3	4	5
g.	We rely on established procedures and practices to do the work	1	2	3	4	5
h.	Our tasks require the use of many skills	1	2	3	4	5
i.	Work information can be interpreted in several ways	1	2	3	4	5
j.	We face problems which have more than one acceptable solution	1	2	3	4	5
k.	Information about work activities can mean different things to different members of my department	1	2	3	4	5
l.	The information we have is adequate for making good work decisions about my department's tasks or problems	1	2	3	4	5
m.	I can tell if my decisions affect my department's performance	1	2	3	4	5
n.	My job requirements are clear to me	1	2	3	4	5

OTHER DEPARTMENTS/OFFICES

2. How well do these statements describe the INTERNAL environment of your organization at your work site, but outside of your department?

		Strongly Disagree				Strongly Agree
a.	There are frequent technical, economic, and/or organizational changes which directly affect my department's activities	1	2	3	4	5
b.	These changes can usually be anticipated ..	1	2	3	4	5
c.	The internal environment that my department must contend with is made up of many different individuals and departments	1	2	3	4	5
d.	There are frequent changes in the "best" methods for doing our work	1	2	3	4	5
e.	My department knows what to expect in dealing with other departments	1	2	3	4	5
f.	There are many different individuals or departments that affect our work	1	2	3	4	5

INTER-DEPARTMENTAL ACTIVITIES

3. Think of ONLY those work activities that involve coordination with other departments.

		Strongly Disagree				Strongly Agree
a.	Information about COORDINATING work can be interpreted in several ways	1	2	3	4	5
b.	More than one satisfactory solution exists for ways to COORDINATE work activities with other departments	1	2	3	4	5
c.	Co-workers interpret interdepartmental COORDINATION policies differently	1	2	3	4	5

	Strongly Disagree				Strongly Agree
d. I can identify the effect decisions about work COORDINATION have on my department's performance	1	2	3	4	5
e. My job requirements are clear for COORDINATING work with other departments	1	2	3	4	5

WORK-RELATED COMMUNICATION

4. How IMPORTANT are these in performing your present professional duties?

	Very Unimportant				Very Important
a. Face-to-face conversations	1	2	3	4	5
b. Written communications	1	2	3	4	5
c. Electronic mail	1	2	3	4	5
d. Voice mail	1	2	3	4	5

5. In a typical week, approximately how many times do you use each of these <u>in your job</u>?

a. __________Number of face-to-face conversations per week

b. __________Number of written communications per week

c. __________Number of electronic mail messages per week

d. __________Number of voice mail messages per week

6. How <u>accurate</u> is the information you receive through:

		Not Accurate				Very Accurate
a.	Face-to-face conversations	1	2	3	4	5
b.	Written communications	1	2	3	4	5
c.	Electronic mail	1	2	3	4	5
d.	Voice mail	1	2	3	4	5

7. How <u>useful</u> is the information you receive through:

		Not Useful				Very Useful
a.	Face-to-face conversations	1	2	3	4	5
b.	Written communications	1	2	3	4	5
c.	Electronic mail	1	2	3	4	5
d.	Voice mail	1	2	3	4	5

8. How <u>specific</u> is the information you receive through:

		Not Specific				Very Specific
a.	Face-to-face conversations	1	2	3	4	5
b.	Written communications	1	2	3	4	5
c.	Electronic mail	1	2	3	4	5
d.	Voice mail	1	2	3	4	5

9. **How <u>sufficient</u> is the information you receive through:**

	Not Sufficient				Very Sufficient
a. Face-to-face conversations	1	2	3	4	5
b. Written communications	1	2	3	4	5
c. Electronic mail	1	2	3	4	5
d. Voice mail	1	2	3	4	5

10. **How <u>easy</u> is it to get the information you need through:**

	Not Easy				Very Easy
a. Face-to-face conversations	1	2	3	4	5
b. Written communications	1	2	3	4	5
c. Electronic mail	1	2	3	4	5
d. Voice mail	1	2	3	4	5

11. **How <u>often</u> do you seem to receive <u>more</u> information than you can effectively use through:**

	Never	Seldom	Sometimes	Frequently	Always
a. Face-to-face conversations	1	2	3	4	5
b. Written communications	1	2	3	4	5
c. Electronic mail	1	2	3	4	5
d. Voice mail	1	2	3	4	5

COMMUNICATION METHODS

12. **In a typical week, approximately how many times do you use each method to obtain information from other members of your department?**

Number of Times Per Week

a. __________Formal written reports

b. __________All other written documents (e.g., letters, memos, notes)

c. __________Electronic mail

d. __________Telephone voice mail

e. __________Actual telephone conversations

f. __________One-on-one conversations (speaking face-to-face with one other person)

g. __________Liaisons (talking to people who act as formal representatives of others)

h. __________Meetings (speaking face-to-face with two or more persons)

13. **In a typical week, approximately how many times do you use each method to obtain information from others outside your department?**

Number of Times Per Week

a. __________Formal written reports

b. __________All other written documents (e.g., letters, memos, notes)

c. __________Electronic mail

d. __________Telephone voice mail

e. __________Actual telephone conversations

f. __________One-on-one conversations (speaking face-to-face with one other person)

g. __________Liaisons (talking to people who act as formal representatives of others)

h. __________Meetings (speaking face-to-face with two or more persons)

14. **In a typical week, approximately how many times do you use each method to provide information to other members of your department?**

Number of Times Per Week

a. __________Formal written reports

b. __________All other written documents (e.g., letters, memos, notes)

c. __________Electronic mail

d. __________Telephone voice mail

e. __________Actual telephone conversations

f. __________One-on-one conversations (speaking face-to-face with one other person)

g. __________Liaisons (talking to people who act as formal representatives of others)

h. __________Meetings (speaking face-to-face with two or more persons)

15. **In a typical week, approximately how many times do you use each method to provide information to others outside your department?**

Number of Times Per Week

a. __________Formal written reports

b. __________All other written documents (e.g., letters, memos, notes)

c. __________Electronic mail

d. __________Telephone voice mail

e. __________Actual telephone conversations

f. __________One-on-one conversations (speaking face-to-face with one other person)

g. __________Liaisons (talking to people who act as formal representatives of others)

h. __________Meetings (speaking face-to-face with two or more persons)

ELECTRONIC (COMPUTER) NETWORKS

16. Do you ever use electronic (computer) networks? (Circle letter)

a. Yes, I personally use them
b. Yes, I use them but through an intermediary
c. No, because I do not have access to electronic (computer) networks (Skip to Q 22.)
d. No, although I have access to them (Skip to Q 22.)

17. At your workplace, how do you access electronic (computer) networks? (Circle letter)

a. By using a mainframe terminal
b. By using a personal computer
c. By using a workstation

18. How important is the use of electronic (computer) networks in doing your job? (Circle number)

Very Unimportant 1 2 3 4 5 Very Important

19. In a typical past week, how many <u>hours</u> did you use electronic (computer) networks?

__________Hours per week

20. In a typical week, how many <u>times</u> do you use electronic (computer) networks for these purposes?

Number of Times

a. __________To connect to geographically distant sites

b. __________For electronic mail

c. __________For electronic bulletin boards or conferences

d. __________For electronic file transfer

e. __________To log into computers for such things as computational analysis or to use design tools

f. __________To control equipment such as laboratory instruments or machine tools

g. __________To access/search the technical library's catalog

h. __________To order documents from the library

i. __________To search electronic (bibliographic, numeric, and factual) data bases

j. __________For information and/or data search and retrieval

k. __________To prepare research papers with colleagues at geographically distant sites

21. In a typical week, how many <u>times</u> do you use electronic (computer) networks to communicate with:

Number of Times

a. __________Members of your department

b. __________People in your organization (at the **SAME** site) who are **NOT** in your department

c. __________People in your organization (at a **DIFFERENT** site) who are **NOT** in your department

d. __________People outside of your organization

JOB PERFORMANCE

22. These questions pertain to your job performance over the past 12 months. To what extent do you AGREE with the following statements?

	Strongly Disagree				Strongly Agree
a. My performance greatly contributes to accomplishing the organization's goals	1	2	3	4	5
b. My performance is high quality	1	2	3	4	5
c. My planned milestones and activities are completed on time	1	2	3	4	5
d. I get maximum utility from available resources	1	2	3	4	5
e. I anticipate problems and prevent them or minimize their effects	1	2	3	4	5
f. My job performance exceeds the standards for my position	1	2	3	4	5
g. I accept and adjust to changes in work routines and procedures	1	2	3	4	5
h. I cope with unforseen changes made to work routines and procedures better than other members of my department	1	2	3	4	5

DEMOGRAPHICS

Finally, we would like to collect some background information to help analyze the data.

23. Your Gender?

a. Female
b. Male

24. Are you a U.S. Citizen?

a. Yes
b. No

25. What is the highest level of education you have?

a. No degree
b. Bachelors
c. Masters
d. Doctorate
e. Post Doctorate
f. Other (e.g., J.D.) ______________

26. Years of professional aerospace work experience?

__________years

27. Years with present employer?

__________years

28. Type of organization where you work?

a. Academic
b. Government
c. Industry
d. Not for Profit
e. Other (specify) ________________________________

29. Your Age?

____

Over Please →

30. **How many employees are in your organization <u>at your work site</u>?**

__________Number

31. **How many employees are in your department <u>at your work site</u>?**

__________Number

32. **Which of the following BEST describes your present professional duties? (Select ONLY ONE response.)**

a. Research
b. Teaching/Academic (may include research)
c. Administration/Management
d. Design/Development
e. Manufacturing/Production
f. Service/Maintenance
g. Marketing/Sales
h. Private Consultant
i. Other (specify) ______________________________

33. **Was your academic preparation as an?**

a. Engineer
b. Scientist
c. Other (specify) ______________

34. **In your present position, do you consider yourself primarily an?**

a. Engineer
b. Scientist
c. Other (specify) ______________

35. **Is English your first (native) language?**

a. Yes
b. No

THANK YOU!

Mail to:

NASA/DoD Aerospace Knowledge Diffusion Research Project
NASA Langley Research Center
Mail Stop 180-A
Hampton, VA 23681-0001

APPENDIX C

SAMPLES OF SURVEY COVER LETTERS

National Aeronautics and
Space Administration
Langley Research Center
Hampton, Virginia
23681-0001

Reply to Attn of 180A

May 3, 1993

Dear Dr. Kennedy:

The U.S. aerospace industry remains a national and global leader and a critical element in the U.S. economy despite significant challenges from international competitors. Continuing U.S. world leadership in aerospace depends, to a considerable extent, on the ability of U.S. aerospace engineers and scientists to identify, acquire, and utilize technical information. However, we know little about how knowledge diffuses throughout the aerospace industry.

The NASA/DoD Aerospace Knowledge Diffusion Research Project is providing a practical basis for understanding the aerospace knowledge diffusion process and its implications at the individual, organizational, national, and international levels. The need for more frequent and effective use of technical information characterizes the strategic vision of today's competitive aerospace marketplace. There is considerable agreement that computer networks will enhance the productivity of U.S. aerospace engineers and scientists by improving access to technical information, colleagues, computers, and other network resources. However, very little is known about how networks are used in aerospace work and communication and whether they contribute to improved productivity and competitiveness.

The enclosed survey is part of the Aerospace Knowledge Diffusion Research Project. I encourage you to complete and return this survey as soon as possible. Doing so will provide useful information that is needed to develop a set of innovation-adoption technology policy goals for aerospace and a coherent, integrated program directed at attaining these goals. Should you have questions or need additional information, please contact me by telephone at (804) 864-2491 or by email at tompin@teb.larc.nasa.gov.

Sincerely,

Thomas E. Pinelli, Ph.D.
Assistant to the Chief
Research Information and
Applications Division

SUNY Institute of Technology at Utica/Rome

May 3, 1993

John M Kennedy
1022 E Third St
Bloomginton, IN 47401-3779

Dear Dr. Kennedy:

Many aerospace organizations are investing heavily in computer networks, but very little is known about who is using the networks and whether or not they really improve productivity and performance. Consequently, we are conducting a study to learn how people in aerospace use computer networks and other media for their work. Your name is part of a small sample that was provided to us by the AIAA, and we are asking for your opinion on some carefully-chosen, work-related communication activities.

As you know, when interviewing only a small sample, it is important to achieve a high response rate. Please complete the enclosed survey and return it in the enclosed, postage-paid envelope at your earliest convenience. **Even if you do not use computer networks, we care about your views.** The findings of this study will be made available to the aerospace and computer networking communities to help them in their efforts to develop computer network systems, services, and policies that are better suited to people's needs and more likely to achieve projected benefits.

This survey was developed following in-depth discussions involving communication and organization design specialists and aerospace personnel. It should take approximately 20 minutes to complete. The data from the survey will be kept confidential in that no information will be tied to any individual's or organization's identities. You can receive a summary of results by writing your address and "copy of results requested" on the back of your questionnaire. If you have any questions about the study, please contact me by telephone at (315) 792-7322 or by email at murphy@sunyit.edu.

Thank you for your time and cooperation.

Sincerely,

Daniel J. Murphy
Assistant Professor
Department of Technical Communication

A college for transfer and graduate study

State University of New York • P.O. Box 3050, Utica, NY 13504-3050 • FAX 315/792-7222

An equal opportunity/affirmative action employer

SUNY Institute of Technology at Utica/Rome

June 21, 1993

John M Kennedy
1022 E Third St
Bloomington, IN 47401-3779

Dear Dr. Kennedy:

As you may recall, we are conducting a study concerning the use of computer networks and other media in the aerospace industry. Response to this survey has been excellent, but, as of today, we have not received your completed questionnaire.

From previous research, we know that people who do not respond immediately to surveys have different opinions than those who do. Since this issue affects everyone who works in the aerospace industry, it is very important that we include your responses in the survey. Only a small number of people have been asked to complete the questionnaire, so your answers represent the opinions of many others. The findings in this study will be made available to the aerospace and computer networking communities to help them in their efforts to develop computer network systems, services, and policies that are better suited to people's needs and more likely to achieve projected benefits.

Please take 20 minutes to complete the enclosed questionnaire today. The individual data will be kept confidential. If you have any questions about the survey, please contact me by telephone at (315) 792-7322 or by email at murphy@sunyit.edu. If you are no longer involved in aerospace or you have retired, please call the Indiana University Center for Survey Research at 1-800-258-7691 and we will take you off our list.

Thank you for your cooperation in this important study.

Sincerely,

Daniel J. Murphy
Assistant Professor
Department of Technical Communication

APPENDIX D

SAMPLE OF SURVEY FOLLOW-UP POSTCARD

Dear Colleague:

Recently you received a questionnaire asking questions about the potential role of computer networks in aerospace. If you have already returned the questionnaire, please accept our sincere thanks. You have given us information we need to understand more effectively the use of networking systems, services, and policies.

If you have not returned the questionnaire, won't you please do so today? If by some chance you have not received it, please call the IU Center for Survey Research at 1-800-258-7691. A staff member will send you a questionnaire immediately. If you are no longer involved with the aerospace industry, please call us so we can remove you from our list.

Thank you very much for your assistance with this important project.

John M. Kennedy, Director
Center for Survey Research

APPENDIX E

INDIANA UNIVERSITY CENTER FOR SURVEY RESEARCH

DATA REPORT

Survey of Computer-Mediated Communication (CMC) and the Communication of Technical Information in Aerospace
Indiana University Center for Survey Research
April - September, 1993

STUDY OVERVIEW

Background:
The Indiana University Center for Survey Research (CSR) in Bloomington conducted the survey of Computer-Mediated Communication and the Communication of Technical Information in Aerospace. The focus of this study was to determine how people in aerospace use computer networks and other media for their work. The survey was conducted as a part of the NASA/DoD Aerospace Knowledge Diffusion Research Project. Professor Daniel Murphy of State University of New York directed the study. The results will be used to assist aerospace and computer networking communities in developing computer network systems, services, and policies that are better suited to people's needs and more likely to achieve projected benefits.

Fielding:
The survey was conducted between April and September, 1993. Two thousand questionnaires were sent to members of the American Institute of Aeronautics and Astronautics (AIAA) on April 26, and 1171 questionnaires were sent out for the second mailing on June 21. The CSR received a total of 1006 usable questionnaires by the cutoff date of September 7.

Sample:
The names and addresses for the study were provided by AIAA.

CSR MAILING FACILITIES AND PROCEDURES

Pre-Survey Processing:
The CSR imported the sample provided by AIAA into a Paradox database. Each respondent was assigned a unique identification number used throughout the survey process. An initial inspection and cleaning of the data was done. Missing data on the respondents, such as zip codes or incomplete addresses, were searched in an appropriate source.

Questionnaire:
The questionnaire was developed by Daniel Murphy in consultation with the principal investigators of the NASA/DoD Aerospace Knowledge Diffusion Research Project. The first mailing included a questionnaire, a cover letter signed by Daniel Murphy on State University of New York letterhead, a cover letter signed by Thomas Pinelli, the Assistant to the Chief, Research Information and Applications Division of NASA on NASA letterhead, and a postage paid return envelope. The CSR sent another questionnaire when the USPS returned the original questionnaire with a corrected address.

Daniel Murphy, in consultation with the CSR, developed a postcard that described the survey. The CSR send the post card on May 13, reminding respondents to return their questionnaires and thanking those who already had.

The second mailing included a questionnaire, a cover letter signed by Daniel Murphy on State University of New York letterhead, and a postage paid return envelope.

Data Entry:
The data were entered into the computer using the Computer-Assisted Survey Execution System (CASES). With the CASES system, each question appears on a computer monitor and the responses are directly entered into a computer.

Disposition:
As of the cutoff date of September 7, the CSR received a total of 1006 usable questionnaires. Twelve respondents refused to participate in the study. There were 90 incorrect addresses. Thirty-six respondents were retired and 5 respondents were deceased.

Usable Returns	Refusals	Incorrect Addresses	Retired	Deceased	Not Returned
1006	12	90	36	5	851

ERROR

Surveys of this kind are sometimes subject to different kinds of inaccuracies of which precise estimates cannot be calculated and which may, in some cases, be even larger than the effects associated with sampling procedures. For example, findings may be influenced by events which take place while the survey is in the field. Events occurring since the time the surveys were completed could have changed the opinions reported here. Sometimes questions are inadvertently biased or misleading. And people who responded to the survey may not necessarily replicate the views of those who refused to fill out their surveys. Moreover, while every precaution has been taken to make these findings completely accurate, other errors may have resulted from the various practical difficulties associated with taking any sample survey.

CSR STAFF CONTACTS

John Kennedy, the CSR director, directed the survey of Computer-Mediated Communication and the Communication of Technical Information in Aerospace. Tammi Taylor, the assistant field director of the mail survey section, was responsible for survey mailing procedures. Further information regarding this study is available by writing to the Center for Survey Research, 1022 East Third Street, Bloomington, IN 47405, or by calling (812) 855-2573. Daniel Murphy may be reached by telephone at (315) 792-7322 or by email at murphy@sunyit.edu.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1994	Contractor Report (Final)

4. TITLE AND SUBTITLE
Computer-Mediated Communication (CMC) and the Communication of Technical Information in Aerospace*

5. FUNDING NUMBERS
WU 505-90
PO L-45107

6. AUTHOR(S)
Daniel J. Murphy**

7. PERFORMING ORGANZATION NAME(S) AND ADDRESS(ES)
SUNY Institute of Technology at Utica/Rome
P.O. Box 3050
Utica, NY 13504-0001

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORIING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
NASA Langley Research Center
Hampton, VA 23681-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA CR-194973

11. SUPPLEMENTARY NOTES
*Report number 30 under the NASA/DoD Aerospace Knowledge Diffusion Research Project. The information in this report was offered as a Ph.D. Thesis, Rensselaer Polytechnic Institute, Troy, NY. **Daniel J. Murphy, Assist. Prof. of Communications, School of Arts and Sciences, SUNY Inst. of Tech., Utica, NY. Langley Technical Monitor: Thomas E. Pinelli

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified—Unlimited
Subject Category 82

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
This research used survey research to examine the use of communication media in general, and electronic media specifically, in the U.S. aerospace industry. The survey population included 1,006 randomly selected U.S. aerospace engineers and scientists who belong to the American Institute of Aeronautics and Astronautics (AIAA). Survey data were compared with qualitative information obtained from 32 AIAA members in telephone and face-to-face conversations. The Information Processing (IP) model developed by Tushman and Nadler and Daft and Lengel constituted the study's theoretical basis. This research analyzed responses regarding communication methods of U.S. aerospace engineers and scientists who create, use, and disseminate aerospace knowledge and explored selected contextual environmental variables related to media use and effective performance. The results indicate that uncertainty is significantly reduced in environments when levels of analyzability are high. When uncertainty is high, there is significantly more use of electronic media. However, no relation was found between overall effectiveness and media use in environments stratified by levels by analyzability or equivocality. The results indicate modest support for the influences of uncertainty and analyzability on electronic media use. Although most respondents reported that electronic networks are important for their work, the data suggest that there are sharply disparate levels of use.

14. SUBJECT TERMS
Communications, computers, electronic networks, uncertainty, aerospace engineers, electronic media

15. NUMBER OF PAGES
284

16. PRICE CODE
A13

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102